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The report is designed to survey in some detail the activities of several Federal agencies involved in radiation protection-such as controlling medical x-ray exposures, managing nuclear power plant effluents, protecting workers exposed to radiation, and monitoring fallout. In addition some of the less obvious activities are referred to, to give readers a sense of scope of Federal involvement. The division of responsibilities within the Federal government is defined, and some relevant congressional and judicial actions are summarized in the introduction. A list of pertinent 1977 Federal publications is provided.

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1977

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RADIATION PROTECTION ACTIVITIES
1977

An Annual Report Prepared By
U.S. Environmental Protection Agency
Office of Radiation Programs
Washington, D.C. 20460
August 1978

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

To Readers of *Radiation Protection Activities:*

Since 1974 EPA has published this report to consolidate information about radiation protection activities, which take place in several dozen Federal agencies and cover a spectrum from nuclear power to medical x rays. This report is in keeping with EPA's charge to "advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance to Federal agencies in the formulation of radiation standards." We hope it will be useful to those who want an understanding of the full sweep of Federal activities; as in previous years, it will be made available to Congress, key administrative officials, States and the public.

We have established a generic outline to be used every year, so readers may more easily compare activities from one report to the next. Under each source of radiation exposure, substantive areas (such as wastes under nuclear power) are divided into kinds of action — guidance, environmental impact statements, education, enforcement, research. Selected activities, which will vary from year to year, are then discussed briefly under each category.

Rather than presenting an exhaustive examination of each item, we have identified the responsible agency so that people who want more detailed information will know where to find it. Among the most useful sources are the annual reports of other agencies; while none of them catalogs the overall Federal effort like this report, they do provide more detailed data on their own activities. Another good source for further information is the expanded publications list for 1977, Appendix B. It should be noted that this document serves as EPA's own annual report as well as being a comprehensive overview of other Federal agencies, so EPA's activities are necessarily presented in more detail tthan others'.The chapters make no attempt to represent accurately the breakdown of programs or funding in a particular area among the various agencies. Rather, they sample many efforts and show the diversity and scope of Federal involvement.

Each year we attempt to focus the report more clearly and to respond to the comments we receive about it. If you would like to see it modified, or if you have found errors or omissions, please let us hear from you.

W. D. Rowe, Ph.D.
Deputy Assistant Administrator
for Radiation Programs

OUTLINE

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INTRODUCTION

Americans get most of their exposure to radiation from naturally-occurring sources like cosmic rays and soils. Although we can affect it by where we choose to live, whether we travel by air, or how we decide to vacation, a certain amount of exposure is inescapable for each individual.

The purpose of radiation protection is to limit:

— the dose to individuals which is added to the relatively unavoidable amount,

— the total population dose, which is the sum of all doses to individuals over the time period that a radioactive material might reasonably be expected to be available for interaction with people.

Setting Federal policy about how much and what kind of protection the public should have from any one particular source of radiation is certainly complex, since risks and benefits are often uncertain. In terms of exposure to individuals, the major source which almost everyone agrees could be cut down safely and substantially arises from diagnostic x-ray procedures. The possible reduction in individual or even total population exposure by controlling most other sources — the nuclear fuel cycle, consumer products containing naturally-occurring radioactive materials, naval reactors, and so on — is comparatively small because doses are small. However, the nuclear fuel cycle and some mining and fossil fuel sources are important because they can produce radioactive materials which, if discharged, persist in the environment for hundreds of years and longer, possibly exposing large population groups. Likewise, such operations produce waste materials that could result in varying degrees of hazard to different population groups for very long time periods, depending on the amount of control or isolation involved.

This report is designed to survey in some detail the activities of several Federal agencies involved in radiation protection — such as controlling medical x-ray exposures, managing nuclear power plant effluents, protecting workers exposed to radiation, and monitoring fallout. In addition, some of the less obvious activities are referred to, to give readers a sense of the scope of Federal involvement. This introduction will focus on how the jurisdictional pie is sliced in Congress, among Federal agencies, and between Federal and State authorities.

1. Congressional Activities

As will be seen below, many Congressional Committees are involved in radiation protection issues. They are covered both by the Committees with jurisdiction over substantive areas like health or the environment, and by the Appropriations Subcommittees for each agency involved. Enumerating the responsibilities of each Committee would not be helpful to people seeking pertinent hearings, since virtually every Committee could have some reason for being interested in radiation protection: transportation, consumer products, occupational safety, small business, international affairs, executive branch jurisdiction, and so on. Involvement depends on whether Members of a particular Committee are interested in radiation protection. Below are some highlights of pertinent Congressional activities in 1977.

Clean Air Act Amendments

EPA/ORP was given major new responsibilities under the Clean Air Act Amendments, passed in August 1977. They expanded the Agency's mandate to include all radioactive air emissions, covering source, special nuclear and by-product material as defined in the

Atomic Energy Act. Under the timetable established by the Amendments for carrying out the new responsibilities, EPA/ORP will determine by August 1979 which, if any, airborne radioactive pollutants should be regulated because of significant health effects. Various possible modes of regulation and other actions are prescribed by the Amendments, depending on the initial findings.

Radiation Health and Safety Oversight

Comprehensive *Radiation Health and Safety* oversight hearings were held by the Senate Committee on Commerce, Science and Transportation in June 1977 (Serial 95-49). In addition to covering implementation of the Radiation Control for Health and Safety Act, the Committee addressed the work of 32 different Federal agencies. The purposes were to define how to coordinate or clarify the many and sometimes overlapping or conflicting responsibilities, and to assess the adequacy of current efforts. The Committee heard not only from many of the Executive agencies involved, but also from private, scientific, and medical societies, standards setting organizations, and individual scientists.

As part of its examination of health and safety regulation, the Senate Governmental Affairs Committee released a report on radiation safety functions of the Federal government. It recommends that legislative action be taken to grant EPA powers similar to the ones it has over toxic substances, centralizing into one agency all the authority presently diffused among eight executive departments, two independent commissions and five other units.

Department of Energy

The Department of Energy was authorized in Public Law 95-91, signed by President Carter on August 4, 1977. The original legislation was transmitted on March 1, 1977 to bring together the many fragmented energy programs and offices in the Federal Government. DOE owns and operates many nuclear facilities, and is responsible for relevant radiation protection. When it was activated on October 1, DOE consolidated all functions of the Federal Energy Administration, the Federal Power Commission, the Energy Research and Development Administration, and certain authorities from:

— the Department of Interior, including setting of economic terms for leasing public land for energy development, and gathering data on fuel supplies, R&D on mining technology and coal preparation analysis.

— the Department of Defense, over Naval oil reserves and shale reserves.

— the Interstate Commerce Commission, over transportation of oil by pipeline.

— the Department of Commerce, over industrial energy conservation.

— the Department of Commerce, over industrial energy conservation.

— the Department of Housing and Urban Development, over energy conservation standards for new buildings.

Programs requiring large budget outlays include conservation and solar applications, resource applications, energy technology, environment, energy research, and defense programs.

Nuclear Power Issues

There was more legislative activity with respect to nuclear wastes than any other single radiation protection issue. Proposals included a wide variety of provisions touching on the State role in siting storage facilities, how mill tailings should be provided for, ocean dumping of radioactive wastes, and transportation through densely populated areas. There were three major sets of hearings during the year.

First, the Subcommittee on Energy and Environment of the House Interior Committee held Oversight Hearings on Nuclear Waste Management. Testimony was heard from ERDA, NRC and EPA on the scope of the waste problem and the Federal response to it, as well as on the adequacy of the Congressional mandates. A representative of the General Accounting Office summarized findings on Federal waste management practices and the division of responsibility among the agencies. For outside views, both the industry and the public interest community were represented.

Also important was a hearing on *High Level Nuclear Waste* before the Subcommittee on Environment, Energy and Natural Resources of the House Government Operations Committee. Held in Richland, Washington, the focus of the hearing was the waste facility located there, with testimony by the regional EPA, ERDA, and USGS officials as well as by the industry. Subjects covered were the management of high level defense wastes — including their origins, makeup, quantities and locations — and the research and development work conducted by contractors on the commercial nuclear power wastes.

Finally, on July 29 and August 1, hearings on Nuclear Waste Management and Disposal were held before the House Commerce Committee's Subcommittee on Oversight and Investigations. Many concerned companies testified, along with ERDA, NRC and one public interest group. A major purpose of the hearings was to hear about the problems of operating utilities which are beginning to run low on storage pool space for spent fuel elements. Short and long term options were explored, with discussion of the possibility of suspending licensing, financing of new facilities, foreign spent fuel, and other policy issues.

Throughout 1977, there was controversy over development of the breeder reactor, a plutonium powered nuclear plant which breeds more plutonium than it consumes. The President announced his opposition to the reactor in his nuclear power policy statement April 7, on the basis that it would involve an increased risk of further proliferation of nuclear weapons. A number of Congressional Committees held hearings on the subject, including the Subcommittee on Fossil and Nuclear Energy Research, Development and Demonstration of the House Science and Technology Committee. The President vetoed an energy research authorization bill which included the breeder (S. 1811), and the controversy was still unresolved at the end of the year.

The broad issue of exports and proliferation was addressed in a number of bills, including the amendments and variations of three Senate Committees: Governmental Affairs, Energy and Natural Resources, and Foreign Relations. The basic concept was to define U.S. nonproliferation policies within an international framework of nuclear cooperation and safeguards, and to establish effective Federal nuclear export controls. The House International Relations Committee held hearings to clarify Federal agencies' various responsibilities in the field, to provide revised licensing criteria, and to specify U.S. policies on international cooperation (*Nuclear Antiproliferation Act of 1977*, April 4, May 19,26, July 27, 29, August 1, 2, 1977).

Major reform of the process by which nuclear reactors are licensed, now a very lengthy and complex system, was also considered. Some streamlining suggestions were made, and the Administration intended to propose new legislation to that effect in 1978.

2. Executive Branch

Nearly everything the Federal government does in radiation protection is accomplished by the Environmental Protection Agency's Office of Radiation Programs (EPA/ORP), the Nuclear Regulatory Commission (NRC), FDA's Bureau of Radiological Health (BRH) and Bureau of Drugs, the National Institute for Occupational Safety and Health (NIOSH), the Department of Defense (DOD), or the Department of Energy (DOE).

The remaining activities and responsibilities are scattered among many agencies, including the National Bureau of Standards, the Occupational Safety and Health Administration, the Office of Telecommunications Policy, the National Cancer Institute, and the Central

Intelligence Agency. While the discussion which follows is by no means complete, it does show the division of jurisdiction among four of the major agencies involved, and the way a number of multi-agency functions are handled.

Originally, nearly all authority pertinent to radiation protection was or is derived from the Atomic Energy Act and the Public Health Service Act. These basic statutes have been amended many times over and supplemented by Executive Orders; additional relevant laws have been passed, such as the Medical Device Amendments and the Consumer Product Safety Act.

Environmental Protection Agency (EPA)

When EPA was formed in 1970 (by Reorganization Plan No. 3), its new jurisdiction included that of:

— the Federal Radiation Council, a Presidentially appointed, Cabinet level group formed "to advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance to Federal agencies in the formulation of radiation standards . . ." (73 Stat 690).

— radiation protection activities of the Department of Health, Education, and Welfare covered under the Public Health Service Act, except "insofar as the functions . . . pertain to (A) regulation of radiation from consumer products, including electronic product radiation, (B) radiation as used in the healing arts, (C) occupational exposures to radiation, and (D) research, technical assistance, and training related to clauses (A), (B), and (C)" (Reorganization Plan No. 3 of 1970, Section 2). Other functions under the PHS Act involve research and investigation, national health surveys and studies, and Federal/State cooperation in public health.

— the Division of Radiation Protection Standards in the Atomic Energy Commission, "to the extent that such functions of the Commission consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material. As used herein, standards mean limits on radiation exposure or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material" (Ibid.).

Since 1970, EPA's radiation protection authority has been extensively supplemented. The major area of jurisdictional conflict resulting from the additional legislation has been implementation of water quality effluent limitations under the Water Quality Control Act of 1972. The Supreme Court found on June 1, 1976 that EPA is not required to regulate radioactive effluents in discharge permits for nuclear power plants. Before that decision, in January 1976 a new and updated Memorandum of Understanding became effective between EPA and NRC on the preparation and evaluation of environmental impact statements. For all activities covered under the Water Quality Act of 1972:

1. NRC serves as the "lead agency" for preparation of environmental statements.
2. NRC and EPA work together to identify environmental information needed to evaluate the impact on water quality and biota.
3. EPA evaluates such impacts as far as possible in advance of the issuance of NRC's Final Environmental Impact Statement.
4. EPA endeavors to issue, where appropriate, a complete Section 402 permit under the National Pollutant Discharge Elimination System (NPDES) as far as possible in advance of the NRC licensing action (construction permit, operating license, or early site approval).
5. EPA and NRC consider the feasibility of holding combined or concurrent hearings on EPA's proposed Section 402 permits and NRC's proposed licensing actions.

The range of other additional legislation is extremely broad, since almost all of the major bills affecting EPA can include radiation protection in one way or another. Below are some of the most important:

— *Toxic Substances Control Act*, regulating all aspects of hazardous chemical substances and mixtures, including premarket review.

— *Resource Conservation and Recovery Act*, identifying and listing hazardous wastes, applying standards to their generators and transporters, issuing permits for treatment, storage or disposal.

— *Solid Waste Disposal Act*, publishing guidelines for solid waste systems, consulting with agencies which issue disposal licenses or permits.

— *Safe Drinking Water Act*, promulgating drinking water regulations, acting on an emergency basis to protect public health under certain conditions.

— *Clean Air Act*, publishing a list of air pollutants and issuing air quality criteria and standards for each pollutant listed, publishing categories of stationary sources and regulating them, publishing hazardous air pollutants and prescribing emission standards. Also, see above for a discussion of the 1977 Amendments.

— *Marine Protection, Research and Sanctuaries Act*, allowing permits to be issued for ocean dumping of radioactive substances under certain conditions.

Nuclear Regulatory Commission (NRC)

Broadly speaking, the Atomic Energy Commission was split into its development (ERDA) and regulatory (NRC) parts by the Energy Reorganization Act of 1974 (88 Stat 1233, PL 93-438). NRC became responsible for the "licensing and regulatory functions" relating to commercial nuclear facilities, and to some facilities of the development arm (formerly ERDA, now DOE). Therefore, NRC must implement radiation protection standards, both by defining specific requirements in the licenses of individual plants and by enforcing them.

The other major area of NRC responsibility is the regulation of:

—"*source material*," meaning uranium or thorium, or ores of a certain concentration of either or both;

— "*by-product material*," meaning any radioactive material (except below) yielded in, or made radioactive by, producing or using special nuclear material;

— "*special nuclear material*," meaning plutonium, uranium-233, uranium enriched in the isotope 233 or 235, any material enriched by the foregoing, and any other material designated by the NRC. Much of the regulating of these materials is actually carried out by the States rather than by the NRC itself.

Department of Energy (DOE)

DOE performs the great bulk of research on the biomedical, environmental, physical and safety aspects of nuclear and other kinds of energy. It is also responsible for radiation health and safety and environmental protection at DOE facilities, as part of their construction, operation and decommissioning.

Bureau of Radiological Health (BRH)

The Food and Drug Administration's BRH has many general public health responsibilities associated with radiation protection. It conducts an electronic product radiation control program, including the development and administration of performance standards. As the agency primarily responsible for radiation used in the healing arts, the Bureau develops criteria, recommendations, and standards relative to radiation equipment use and exposure, as well as developing improved techniques, procedures and users' qualifications for reducing unnecessary exposure. BRH also provides advice to the Bureau of Foods and the Bureau of Drugs on the control of radioactive materials and radiation in food and drugs. Other functions include research, technical assistance and training in occupational radiation exposure; research on health effects of radiation exposure; and participation in the development of model state codes and recommendations.

Multi-Agency Responsibilities

Occupational Exposure

As part of its inheritance from the Federal Radiation Council, EPA is responsible for general Federal guidance for occupational exposure. NRC and DOE establish implementing standards for workers (including medical licensees) covered under the Atomic Energy Act; for uranium, phosphate and other miners, the Mining Health and Safety Administration in the Department of Interior performs the same function. BRH has traditionally provided implementing recommendations to the States for workers in the health professions. The Occupational Safety and Health Administration (OSHA) establishes regulations for workers who are exposed to radiation and not already protected by another agency's standards.

Nuclear Export Licensing Policy

While NRC has responsibility for final decisions about licensing export of nuclear materials and equipment, a 1976 Executive Order (E.O. 11902, February 2, 1976) defines procedures for involving other agencies. They apply to specific export license applications, general licenses for export, and proposed exemptions from the requirement for a license. To produce an executive branch position on the effect on the common defense and security, the Secretary of State is to consult with the Secretaries of Defense and Commerce, the DOE, and the Director of the Arms Control and Disarmament Agency.

Radioactive Materials Transportation

NRC, the Department of Transportation (DOT), the U.S. Postal Service, and the States all have a part in regulating the safety of commercial shipments of nuclear material. NRC regulations apply to its licensees and generally specify procedures and standards for packages and shipments. DOT regulates certain types of packaging, labeling and conditions of carriage. Since DOT and NRC jurisdictions overlap, the agencies operate under a Memorandum of Understanding in order to provide consistent, comprehensive and effective regulation without duplication. The Postal Service regulates shipments of nuclear materials by mail, and the States have regulatory authority over intrastate transport of nuclear materials.

Consumer Products

Jurisdiction over consumer products containing radioactive material is incomplete and extremely complex. Five different Acts may be used to regulate risks associated with products: the Occupational Safety and Health Act (by OSHA), the Atomic Energy Act of 1954 (by NRC or Agreement States, discussed below), the Clean Air Act (by EPA), or the Radiation Control for Health and Safety Act (by BRH).

If none of these can adequately reduce or eliminate the risk — and if the radioactive substance involved is not regulated by NRC — the Consumer Product Safety Commission may act. It can require appropriate branding and labelling of products containing radioactive substances, as long as it determines that the material is sufficiently hazardous to warrant control.

Emergency Response Planning

The Federal effort to develop and improve emergency response planning for radiological incidents includes provisions for assistance to State and local governments in making plans for fixed facilities and transportation. Led by the NRC, agencies involved include EPA, DOE, DOT, HEW, the Defense Civil Preparedness Agency, and the Federal Disaster Assistance Administration. Responsibilities among them are assigned by the Federal Preparedness Agency of the General Services Administration; the current division of labor was published in the *Federal Register* on December 24, 1975.

3. Federal/State Jurisdiction

While the States may not regulate, control or restrict any NRC activities (except in light of the 1977 Clean Air Act Amendments), they can and generally do regulate x-ray facilities and use, as well as radioactive materials not controlled by NRC. Forty-eight States and Puerto Rico have their own enabling acts for radiation protection, and 21 have specific statutes to control nonionizing radiation. In addition, although Federal radiation control authorities dominate the field and generally preempt States, many statutes include provisions permitting Federal authority to be delegated to States through individual agreements. Two of the most important laws with such provisions are the Atomic Energy Act and the Federal Water Pollution Control Act (FWPCA).

The Atomic Energy Act (as amended by Section 274) authorizes NRC to relinquish to a State its regulatory authority over by-product, source and special nuclear materials not sufficient to form a critical mass. As of the end of 1977, there were 25 Agreement States exercising regulatory jurisdiction over approximately 10,700 "agreement material" licenses, as compared to about 8,500 such licenses administered directly by the NRC. As required by the Act, NRC conducts an annual formal review of State programs to assure continuing compatibility. NRC also provides training courses; exchanges current information on regulations, licensing, inspection and enforcement; and consults with State officials.

Similarly, EPA has agreements with 27 "permitting States" under FWPCA. They were contacted in March 1976 by the National Governors' Conference to promote early cooperation with NRC in licensing nuclear power plants and related facilities. Suggesting that States might enter into agreements modeled after the principles of the NRC/EPA Memorandum of Understanding, the Conference stimulated favorable response from nine States.

To help make State programs compatible and to some degree uniform, the Council of State Governments published *Suggested State Regulations for the Control of Radiation* in cooperation with Federal agencies. Those responsible for helping with periodic revision and updating are NRC, BRH, EPA, and particularly the Conference of Radiation Control Program Directors.

On June 10, 1977, the NRC distributed for public comment a draft report entitled "Improving Regulatory Effectiveness in Federal/State Siting Actions" (NUREG—0195). This report was the culmination of some nine months of intensive study by the NRC staff in cooperation with State representatives and other groups.

The study team identified a broad concept of an effective regulatory system, in which the Federal role is primarily to determine the *effect* of proposed actions and in which States have an increasing role in determining the *acceptability* of actions within their purview. The role of States would include determining the acceptability of actions which affect local affairs and which require matching of State and local services to the needs of large projects. By early involvement of States in the planning process and by cooperative use of the technical resources of the Federal government, meaningful regulatory reform would provide for early identification of suitable sites, for increasing the assurance that utilities can proceed with needed facilities, and for greater public participation in the process.

II. NATURALLY-OCCURRING RADIOACTIVE MATERIALS

1. Introduction and Summary

Most Americans are exposed to about the same magnitude of radioactivity from naturally-occurring sources, including cosmic rays, materials originating beneath the earth's crust, and a small amount from radioactive gases in the air. However, there are significant variations in exposure because of high concentrations of uranium, thoron and their decay products in soil; also, cosmic radiation varies considerably with land elevation and altitude above sea level. Exposure may also differ in accordance with individual lifestyles — because of more air travel, for instance.

One of the important naturally-occurring sources of exposure is mined and processed ores originating in strata containing significant concentrations of uranium, thorium and their daughter products. As long as they are confined deep in the earth, the ores have little impact on people because of the ground cover. However, when they are mined, separated, processed into consumer products and distributed, potential exposure to the population is increased. While people of course do not cause the natural radioactivity in the ores, they can increase and concentrate it by technological processes. Some of the industries where this takes place are phosphate, rare earth and several other mining concerns, as well as newer and less developed processes such as geothermal power production.

Radioactive substances can affect people and their environment through four basic pathways:

— as gases and particulates which are released to the air, becoming available for possible human inhalation and lowering the overall air quality.

— as materials in ores or the associated byproducts which may enter ground and surface waters by effluent discharges, land runoff, and leaching from waste piles.

— from close contact between workers and radioactive materials throughout mining and processing.

— from radioactive materials that have entered the food chain.

Because naturally-occurring radioactive materials have the potential for exposing large portions of the population, Federal agencies are extensively involved in identifying and assessing the public health and environmental problems associated with its various sources. Substantial problems have emerged, and analyses of new technologies are only beginning.

Following are highlights of executive branch activities, arranged by source of radiation:

— Uranium mining and milling tailings: NRC proceeded with development of a Generic Environmental Impact Statement covering uranium milling, with particular emphasis on mill tailings. EPA reviewed several Statements on uranium mining and milling facilities, and investigated the new solution mining process. Results were published of engineering assessments by EPA and DOE of 23 tailings piles, and EPA/ORP and NRC began a joint study of uranium mill effluents. EPA/ORP's Las Vegas Facility completed several surveys at individual sites.

— Coal: NRC undertook several new studies on the impacts of using coal for generating electricity, and published the results of an Argonne National Laboratory study on environmental effects. EPA and DOE cosponsored an evaluation of the radioactive emissions from coal fired plants using Western coal.

— Mineral extraction industry: Along with the State of Florida, EPA/ORP evaluated representative homes built on reclaimed and mineralized phosphate lands. Proposed final recommendations on construction were drafted as well as a technical analysis. EPA/ORP also supported a contract to assess the radiological impact of uranium recovery from phosphoric acid.

— Water: The National Interim Primary Drinking Water Regulations became effective on June 24, 1977, restricting the levels of natural and manmade radionuclides in community water systems.

— Other sources: EPA/ORP began implementing relevant portions of the Resource Conservation and Recovery Act, which provides for regulation of the management of hazardous wastes. Radium-226 was selected as the first nuclide for which criteria will be developed under the Act.

2. Executive Activities by Source of Radiation

a. Uranium Mining and Milling Tailings

The uranium in the ore extracted by mining is separated and concentrated in milling operations, which result in the accumulation of large quantities of waste product material called tailings. Composed primarily of ore residues, they contain almost all of the radioactivity that was originally present in the ore. Tailings are a waste management problem because of the large quantities involved, and because of the long half-life of the radionuclides.

As an indication of quantity, a typical mill may generate 1,800 metric tons per day of tailings solids slurried in 2,500 metric tons of waste milling solutions. Over the lifetime of the mill, 100 to 200 acres may be permanently committed to store this material. The tailings piles will have a radiological impact on the environment (1) through the air pathway by continuous discharge of radon-222 gas (a daughter of radium-226), (2) through gamma rays given off by radium-226, radon-222 and daughters as they undergo radioactive decay, and (3) finally through air and water pathways, if radioactive particulates are blown off the pile by wind or radionuclides are leached from the pile due to water seepage.

Solids are being stored at mills by constructing a dike and filling the diked area with slurried tailings. Some of the older mills and all new mills use a clay-core retention dam and various kinds of seepage return systems to control seepage from the tailings ponds. However, in addition to creating a pile which is difficult and costly to stabilize, the dikes are subject to the possibility of structural failures such as the one at the United Nuclear Homestake Partners Mill in New Mexico in 1976.

Uranium mill tailings piles contain long halflife radioactive wastes, and therefore require long-term care. This should include fencing, posting, monitoring, inspection and continual maintenance to assure integrity of the stabilizing cover.

As of December 1977, 18 uranium mills were in operation, all located in Western States. (See Table 2.1.) The various active mill sites already contain over 100 million tons of tailings. There are also a number of new mills presently under construction or in the planning stage.

In non-Agreement States, NRC evaluates uranium milling operations and the conditions of mill tailings piles. This activity includes reviews of uranium mill licenses to evaluate the adequacy of the supporting information in the license files; on-site visits to determine the adequacy of uranium mill inspections; observation of the condition of stabilized and unstabilized mill tailings piles; and reviews of the licensees' environmental surveillance programs.

After an operating license is terminated and a site has been reclaimed, NRC performance objectives include the concept that surety arrangements should be provided to complete the full reclamation plan. These should ultimately eliminate the need for an ongoing monitoring and maintenance program. Specifically, the radon emanation rate from the impoundment area should not exceed about twice that of the surrounding area, and direct gamma radiation should be reduced essentially to natural background levels. (These objectives are not legally binding.)

TABLE 2.1 STATUS OF ACTIVE URANIUM SITES IN THE UNITED STATES AS OF DECEMBER 1977

(18 active--3 active standby)

State	Location	Name and/or Owner	Year Mill Started	Nominal Mill Capacity (Tons Ore per Day	Tons of Tailings (In millions)	Reported Size of Tailings Pile (Acres)
*Colorado	Rifle	Union Carbide	1958-1972 1977	700	2.7	32
	Canon City	Cotter Corporation	1958	150-450	1.1	35
	Uravan	Union Carbide Corp.	1950(a)	0-1300	7.0	80(c)
*New Mexico	Ambrosia Lake	Kerr-McGee Nuclear	1958	3600-7000	25.4(b)	200(c)
	Blue Water	Anaconda Company	1953	3000	15.3(b)	250(c)
	Grants	United Nuclear-Homestake Partners	1958	1650-3500	18.7(d,b)	150(f)
	Moquino	Sohio	1976			
	Churchrock	United Nuclear	1977	3000		
South Dakota	Edgemont(e)	TVA (Mine-Development, Inc.)(e)	1956	250-500	2.000	82
*Texas	Falls City	Conoco & Pioneer Nuclear, Inc.	1971	220-1750	2.600	200
Utah	La Sal	Rio Algom Corporation	1972	500	.74	45
	Moab	Atlas Corporation	1956	800-1500	7.8	120
*Washington	Ford	Dawn Mining Company	1957	0-400	1.9	100
Wyoming	Gas Hills	Federal American Partners	1959	500-950	4.0 (b)	100
	Gas Hills	Utah International, Inc.	1956	750-1200	5.5	135
	Gas Hills	Union Carbide Corporation	1960	1000	4.0	61
	Jeffrey City	Western Nuclear, Inc.	1957	400-1200	3.0	60
	Powder River Basin	Highland Mill, Exxon, U.S.A.	1972	2000	2.2	250
	Shirley Basin (e)	Petrotomics Company (g)	1962	525-1500	4.5 (b)	50
	Shirley Basin	Utah International, Inc.	1971	1200	1.8 (b)	250
	Bear Creek	Rocky Mountain Energy	1977	1000		

(a) Ore processed at the Vanadium facility for the Manhattan project in 1943.
(b) Estimated.
(c) Estimated from topographic map of site.
(d) Includes 1,200,000 tons from salvaged Homestake-New Mexico Partners Mill that was located on the present active site.
(e) Although the site license is still active, there is no present milling activity.
(f) Designated impoundment area.
(g) Mill will reopen January 1, 1978, and handle about 1,600 tons per day.

*Agreement States which have responsibility for licensing the mills. All others are licensed by NRC.

Environmental Impact Statement

NRC's Generic Statement

Because of questions raised concerning the potential effects of expanding uranium milling operations on the environment, the NRC decided in 1976 to prepare a generic environmental impact statement (GEIS) covering uranium milling, with particular emphasis on mill tailings. In the GEIS, the local, regional and national environmental impacts of milling operations to the year 2000 will be assessed and, if warranted, regulatory changes to enhance environmental protection will be recommended.

Work on the GEIS went forward during fiscal year 1977. Its scope and outline were published in the *Federal Register* in March 1977 for public comment. Over 20 letters of comment were received from the public, industry and other Government agencies. The staff has taken these comments into account in developing the study.

A draft of the GEIS is expected to be issued for public comment in August 1978. NRC's intent is also to publish for public comment proposed rules or legislative changes related to uranium milling no later than the time of publication of the final GEIS.

During preparation of the GEIS on uranium milling, the staff is requiring mill operators to commit themselves to a definite plan for tailings management and final disposal. As a prerequisite for receiving a license, each mill operator must also make financial arrangements which assure that sufficient funds will be available to complete disposal of the tailings according to the approved plan. The plan and the financial arrangements are made license conditions.

EPA Reviews

EPA/ORP reviewed several Environmental Statements on uranium mining and milling facilities in 1977. Because of the President's decision against reprocessing, the natural supplies of uranium and means of extracting them have come under much closer scrutiny. In its reviews, EPA/ORP has emphasized the need for a good stabilization program for tailings, and, in the case of open pit mines, for adequate reclamation plans and capacities.

Studies

Uranium Solution Mining Impacts

EPA/ORP began investigating the environmental impacts of a new process of producing uranium. In 1977, air data were collected, and groundwater will be studied by NRC in 1978. The process, solution mining, will enable industry to mine deposits with ore grades considered too small for the conventional process with less surface disruption than formerly. It also has the advantage of making some low assay ores profitable to mine for the first time. After a hole is drilled into the deposit, a solution which dissolves uranium is pumped in and extracted, and the uranium is then removed from solution in a surface plant.

Uranium Mill Effluents

In 1977, EPA, NRC and the State of New Mexico began a joint study with the industry of uranium mill effluents, first examining the Grants, New Mexico mill. Three categories of effluents will be studied to characterize and measure the radionuclides involved: releases from mill vents and stacks; ore, concentrates and waste products: and release rates from ore and tailings piles. The Argonne National Laboratory, acting on NRC's behalf, is characterizing the ore, concentrates and waste products, while EPA has initial responsibility for airborne particulate measurements.

Joint Engineering Assessment

Reports were published in 1977 of the engineering assessments of 23 inactive uranium mill tailings piles listed in Table 2.2, in the second phase of a joint comprehensive study by EPA and DOE. Each report assesses the magnitude of the hazard associated with each site, estimates health effects (mostly from radon), identifies reasonable remedial action options and evaluates their costs. The costs range from less than $50,000 to as high as $30 million per site; the high figure represents the cost of removing a tailings pile to another location for permanent stabilization. DOE will work with the Congress, the States involved, EPA and other appropriate authorities to determine what action should ultimately be taken.

In June 1977, EPA/ORP's Las Vegas Facility published the results of a study, "Radiological Survey at the Inactive Uranium Mill Site Near Riverton, Wyoming" (EPA Technical Note ORP/LV-77-2, June 1977). Conducted at the request of the State, the survey was primarily designed to delineate areas which are contaminated by windblown material from the tailings pile. About 460 acres were found to be contaminated above background levels. Secondary purposes were to collect water samples from local wells, and to collect indoor radon progeny (working level) samples in structures near the site, to identify any major radiation exposures which may be occurring through those pathways. None of the limited number of samples taken exceeded the applicable current guidance.

Another survey undertaken by the Las Vegas Facility was also published in 1977, "Outdoor Radon Study (1975-1975): An Evaluation of Ambient Radon-222 Concentrations in Grand Junction, Colorado" (EPA Technical Note ORP/LV 77-1). As a joint venture with the Colorado Department of Health, the survey updated a 1967 Public Health Service study. The major conclusions were:

— The mean annual radon concentration measured above the tailings pile after stabilization is three times higher than before stabilization, probably because the soil containing radium is now buried below a protective layer and is therefore dryer. Before stabilization, water in the soil helped to contain the radon.

— Radon levels are elevated to a distance of about one and one-half miles from the center of the tailings pile, not one-half mile as concluded in the 1967 study.

b. Coal

Radioactivity in coal used for power generation has received more attention since utilities have increased their use of Western coals, some of which contain more uranium than Eastern ones. The concentration of radium-226, one of the critical radionuclides, varies with ash content and many other factors; it generally averages about one pCi/g, although specific coal beds may contain a much higher concentration.[1]

Extensive surveys by the U.S. Geological Survey have shown that concentrations of uranium range as high as .1 percent in some mineralized lignite beds of North and South Dakota.[2] For unmineralized deposits, concentrations were similar to those found in Eastern coal types. In general, bituminous and lignite deposits contain more uranium than anthracite.

A well run coal-fired power plan releases a small fraction of the coal's total radioactivity in the form of airborne fly ash, with some of the remaining ash handled in ways that could expose the public.[3] NRC has sponsored a generic study to collect available data and assess the public health and safety impacts of the coal fuel cycle.

NRC Studies

On January 25, 1977, an Atomic Safety and Licensing Appeal Board rendered a decision (Hartsville Nuclear Plant) which essentially directed that the NRC staff examine environ-

[1] Jaworowski, A.; Bilkiewica, J.; Kownacka, L.; and S.Wlodek. "Artificial Sources of Natural Radionuclides in the Environment, Natural Radiation Environment II." In *Proceedings of the Second International Symposium on Natural Radiation Environment* (August 1972).

[2] Swanson, V.E.; Huffman, C., Jr.; and J.C. Hamilton. "Composition and Trace-Element Content of Coal, Northern Great Plains Area." U.S. Department of Interior Open-File Report (February 1974).

[3] Martin, J.E.,"Comparative Population Radiation Dose Commitments of Nuclear and Fossil Fuel Electric Power Cycles." In *Proceedings, 8th Midyear Topical Symposium of the Health Physics Society.* U.S. Department of Interior Open-File Report: CONF-741018, pp. 317-326 (1976).

Table 2.2

STATUS OF IN SITU SOLUTION MINING OF URANIUM IN THE U.S.

Docket No.	State, Location	Name and/or Owner	Type of Operation	Year Started	Type of * Leachant (Lixiviant)	Possession Limit (pounds) (Maximum)
	Colorado					
	Weld County	Wyoming Mineral Co.	R+D	1977	Basic	
	Texas (See Next Page)					
	Utah					
40-8434	LaSalle, San Juan City	Homestake Mining		1975		1,000 1/
40-7869	Hanksville, Garfield City	Plateau Resources		1970		30,000
	Wyoming					
40-6622	Shirley Basin	Utah International	Pilot/ Commercial	1966-1969	Acid	20,000 2/
40-8348	Sweetwater County	Minerals Exploration	Pilot	1974	Basic	500 3/
				1976	Basic	
40-8380	Bear Creek, Converse City	Rocky Mountain Energy	Pilot	1975	Acid	6,600
	Nine Mile Lake, Converse City	Haliburton	Pilot	1976	Acid	6,600
40-8064	Highland Mill Site, Converse City	Exxon Minerals USA	Pilot	1970	Basic	50,000
40-8511	Charlie Site, Johnson City	Cotter Corporation	Pilot	1976	Basic	1,000
40-8200	No. Rolling Draw Site, Campbell Cty.	Cleveland Cliffs Iron Co.	Pilot	1974	Basic	500
40-8304	Irigaray Site, Johnson City	Wyoming Minerals Corp.	Pilot	1974	Basic	1,000
Applications in, Actions Pending						
40-8566	Campbell City	Cleveland Cliffs Iron Co.	Pilot		Basic	2,000
40-8663	Powder River Basin, Crook City	Nuclear Dynamics	Pilot		Basic	5,000
40-8586	Double Eagle, Carbon City	Kerr McGee Nuclear	Pilot		Basic	5,000
40-8102	Highland Mill Site, Converse City	Exxon Minerals	Commercial		Basic	300,000
40-8502	Irigaray Site, Johnson City	Wyoming Mineral Corp.	Commercial		Basic	500,000
40-8636	Sweetwater City	Wold Nuclear Co.	Pilot		Acid	3,0000

1/ Uranium recovery from minewater expired 12/31/1976
2/ No longer in operation, terminated 1969
3/ 2 Sites: One in 1974; one in 1976

* Acid indicate H_2SO_4 toxidant e.g. H_2O_2 O_2O_2

Basic indicates M HCO_3+M_2CO_3+Oxidant H_2O_2 O_2O_2

11(b).

Table 2.3

Commercial Uranium Solution Mining Operations in Texas

1977

Licensee	Location	Status
ARCO	George West	Large in situ operation and dryer. (1,200,000 lb.) Open pit mining being considered.
Cheveron U.S.A.	Panna Maria	Mill & mine operation application submitted June 1977, license issued Oct 28, 1977.
Conoco-Conquista	Falls City	Mill operation of about 2500 tons/day. Mill under expansion for Exxon ores.
Mobil	Bruni	In situ plant (300,000 lbs)
Solution Engineering, Inc.	Falls City	Extracting U from tailings ponds of old SW Mill (300,000 lbs.)
Union Carbide	Benevides	In situ mining project (200,000 lbs.)
U.S. Steel	Live Oak County	In situ production (250,000 lbs.)
Wyoming Minerals Corp.	Bruni	In situ mining project (1,200,000 lbs.)

mental effects, including health effects on human and animal life, of the emissions from coal plants, and do so to the same degree that they have for nuclear plants. It also recommended that the staff accord more nearly equal treatment to all environmental considerations, rather than focusing mainly on economic factors. Although identical treatment in every aspect of the environmental comparison may not be required, this kind of critical comparison goes to the heart of NRC's duty under NEPA, since coal and nuclear power. As a result, the NRC staff prepared alternatives to oil as sources of electrical power. As a result the NRC staff prepared testimony comparing the health effects of coal and nuclear plants for both hearings then under way and as part of the environmental statements being prepared. In the testimony—and in the draft of NUREG-0332, "Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives"—mortality and morbidity rates were estimated according to current knowledge of the health effects of contemporary component designs and current operation of fuel cycle facilities, and in anticipation of emission rates and occupational exposures for facilities expected to go into operation between the present and 1985. Although it was shown that the coal fuel cycle alternative has a greater adverse effect on human health than the uranium fuel cycle, the increased risk of adverse health effects for either fuel cycle option represents a very small increase in risk to the health of the average individual in the public sector.

In order to evaluate such effects for the future, the NRC supported a study at Argonne National Laboratory. The results of the study have been published in "The Environmental Effects of Using Coal for Generating Electricity" (NUREG-0252). The NRC also initiated several other studies during fiscal year 1977 to provide further details and greater accuracy in the analytical evaluation of the adverse health effects associated with various fuel cycle alternatives. Among these are the study entitled "Impacts of the Coal Fuel Cycle," and a study initiated at the Argonne National Laboratory of "Projection Models for Health Effects Assessment." Completion of these tasks may provide a basis for further improvement in the health effects comparisons for both fuel cycles.

Assessment of the Radiological Impact of Western Coal

DOE completed the first phase of an EPA-cosponsored study to determine whether there is a potential environmental problem due to radioactive emissions from coal-fired power plants using Western coal. Preliminary indications are that the primary part of the small radiological impact is from wastes due to combustion rather than from other stages in the energy production process. To test that hypothesis, Phase II will include an examination of the entire cycle from mining to wastes, characterizing the distribution of radioactivity and its impacts throughout. Among the pathways of concern are radium contamination of water supplies, particulates from waste piles, radon emanation and the use of wastes in construction materials. This effort is being coordinated with the current Clean Air Act assessment of fossil fuel utilization to avoid duplication.

c. Phosphate Mining & Milling

As long as naturally-occurring radioactive materials remain in the depths of the earth, they have little effect on people and the surface environment because of many feet of soil and rock. However, numerous industries mine, bring to the surface, and process raw materials containing significant concentrations of uranium, thorium and their daughter products.

The phosphate mining and manufacturing industry provides an example of the problems that can result from redistribution of radioactive material in the surface environment. In central Florida alone, about 37 million tons of phosphate rock are processed each year (about 80% of U.S. production). The radiological impact is considerable, as shown in Table 2.3. It presents the results of EPA/ORP's analytic determinations of radium-

Table 2.4

RADIUM – 226, URANIUM AND THORIUM CONCENTRATIONS IN FLORIDA PHOSPHATE MINE PRODUCTS AND WASTES (20)

MATERIAL	RADIUM – 226 (pCi/GRAM)	URANIUM (pCi/GRAM)			THORIUM (pCi/GRAM)			
		234	235	238	227	228	230	232
MARKETABLE ROCK	42	41	1.9	41	2.0	0.61	42.3	0.44
SLIMES	45	42	2.6	44	2.3	1.2	48	1.4
SAND TAILINGS	7.5	5.2	0.38	5.3			4.2	89

Table 2.5

RADIUM – 226, URANIUM AND THORIUM IN WET PROCESS PHOSPHORIC ACID PLANT PRODUCTS AND BYPRODUCTS

MATERIAL	RADIUM – 226 (pCi/gm)	URANIUM (pCi/gm)			THORIUM (pCi/gm)			
		234	235	238	227	228	230	232
GYPSUM	33	6.2	0.32	6.0	0.97	1.4	13	0.27
NORMAL SUPER-PHOSPHATE	21			20			18	0.6
DIAMMONIUM PHOSPHATE (DAP)	5.6	63	3.0	63	1.6	0.8	65	0.4
TRIPLE SUPER-PHOSPHATE (TSP)	21	58	2.8	58	1.2	0.9	48	1.3
MONOAMMONIUM PHOSPHATE (MAP)	5.0	55	2.9	55			50	1.7
SODIUM FLOUROSILICATE	0.28			N.D.			N.D.	N.D.
ANIMAL FEED	5.5							
PHOSPHORIC ACID	<1			25			28	3.1

226, uranium, and thorium concentrations in Florida's phosphate products and wastes.

One set of environmental and health impacts results from the production of phosphoric acid from marketable rock. The usual wet process method — used in 1974 to produce about five million tons of acid from 20 million tons of rock — involves the discharge of radium in liquid effluents, as well as significant concentrations of radium and thorium in products and by-products. (See Table 2.4 for details.)

Other problems stem from the fact that phosphate manufacture involves the accumulation of massive gypsum piles (30-100 feet in height) and the maintenance of large cooling ponds of waste (often about 500 acres). The production of elemental phosphorus results in radioactive air effluents from the thermal milling process, although most of the radioactivity originally in the phosphate ore can be found in the by-product slag.

Studies

Another cause for concern is that reclaimed mining and mineralized phosphate areas—where the soils contain substantially more radium than normal soil—are used extensively for residential and agricultural purposes. EPA/ORP worked to address these concerns by assisting the State of Florida in implementing a radiological survey of representative homes built on reclaimed and mineralized land. Data collection was continued until a full year's exposure was available for study. Pending that data and formulation of final recommendations, EPA/ORP made these suggestions to Florida in 1975:

External Gamma Radiation Level	*Recommendation*
= or greater than 0.01 mR/hr	Construction should be delayed pending study or acceptable control technology should be instituted to preclude indoor radon daughter problems.
Less than 0.01 mR/hr	Construction may be initiated.

Proposed final recommendations and a technical analysis were drafted in 1977, and are expected to be published for comment in 1978 along with the technical support document. Also slated for publication are the results of a survey of fruits and vegetables grown on reclaimed land.

In addition, EPA/ORP supported a contract to assess the radiological impact of uranium recovery from phosphoric acid, an innovative technique which is now being commercialized to extract uranium from the phosphoric acid process stream. It holds great promise not only as a source of uranium, but also as a measure to reduce the amount of uranium released to the environment through fertilizers and other phosphate products and wastes.

Although the phosphate mining and milling industry was the first selected for concentrated effort by EPA/ORP, other mineral extraction industries also have a potential for contributing to occupational and public radiation exposure. Ores such as copper, titanium and beryllium, depending upon mine location, have shown uranium concentrations high enough to be commercially extractable, especially as the price of uranium rises.

d. Water

Guidance

Radioactivity in Drinking Water

The National Interim Primary Drinking Water Regulations, which became effective on June 24, 1977, restrict levels of natural and manmade radionuclides in community water systems, which includes any public water system serving at least 15 service connections used by year round residents or regularly serves at least 25 year round residents. These regulations, promulgated on December 24, 1975, in accordance with the Safe Drinking Water Act, limit the ingestion of radium-226 to five picocuries per liter and gross alpha particle activity to 15 picocuries per liter. They also restrict the amount of any manmade radionuclides that can be present in community drinking water systems. The total annual dose equivalent from all manmade radionuclides combined cannot exceed four millirems per year. For alpha contaminants, the Regulations provide that initial compliance sampling will begin within two years of the effective date, and will be completed within an additional year. Thereafter, monitoring shall be conducted not less than once every four years. Gross alpha particle activity measurements are used as a screen to determine the need for specific radium isotopic analyses. When the gross alpha particle activity exceeds five picocuries per liter, analysis for radium-226 is required, and also for radium-228 if the radium-226 activity exceeds three picocuries per liter.

Systems serving more than 100,000 persons from surface water supplies, and any other systems designated by the State, are required to analyze for gross beta activity, tritium and strontium-90 within two years of the effective date, and at four year intervals thereafter. When the gross beta activity exceeds 50 picocuries per liter, the major constituents must be determined for calculation of organ and total body doses. Analysis for iodine-131 and other reactor wastes is required if the supply is liable to be contaminated by effluents from nuclear facilities. The State may accept environmental surveillance data obtained from nuclear facility monitoring programs which are conducted in conjunction with State programs.

Primary enforcement responsibility will rest with the State unless it is refused, in which case it reverts to EPA. For radioactivity, all analyses must be made by laboratories approved by the enforcing authority. The principal radiological laboratory for each analysis in a State would be certified by a regional EPA team, supplemented by the Quality Assurance Branch of EPA's Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

e. Other Sources

Radioactive Waste Regulation

The Resource Conservation and Recovery Act (RCRA), signed into law on October 21, 1976, provides for regulation of the management of hazardous wastes. Radioactive waste which NRC does not regulate under the Atomic Energy Act is to be regulated by EPA under RCRA, and EPA/ORP has been given the responsibility of developing Section 3001 and 3004 criteria and standards. Section 3001 provides that, within 18 months of enactment, EPA should promulgate criteria identifying the characteristics of hazardous waste; accordingly, radium-226 was selected as the first nuclide for which criteria are to be developed, with scientific and technical rationales tentatively planned for issuance by mid-1978. Other naturally occurring materials may be selected under Section 3001 at a later time; possible choices include thorium-230, lead-210, polonium-210, thorium 228, and radium-228. According to the provisions of the Section, the determination must take into account "toxicity, persistence, and degradibility in nature, potential for accumulation in tissue, and other related factors such as flammability, corrosiveness, and other hazardous characteristics."

The Agency is also initiating preparation of a background document for Section 3004 regulations covering management of waste containing radium-226. Pertaining to owners and operators of treatment, storage and disposal facilities, this Section mandates the development of standards within 18 months on such matters as siting, compliance with permit requirements, record-keeping for all hazardous wastes, and satisfactory implementation of a manifest system.

III. MEDICAL RADIATION EXPOSURE

1. Introduction and Summary

Medical exposure to ionizing radiation can and should be significantly cut without reducing quality of care, according to experts in the scientific community. As matters stand, over half of the U.S. population receives at least one radiographic examination annually, and medical exposures account for at least 90 percent of the total manmade dose to individuals.[1]

The problem of unnecessary risks associated with medical exposure is compounded by the marked increase in the number of diagnostic examinations performed over the last decade, estimated to range from one to four percent per capita annually. Some significant changes were revealed in surveys of diagnostic x-ray exposures in 1964 and 1970:[2]

— There was a 20 percent increase in the number of persons receiving one or more x-ray procedures, from 108 million in 1964 to 130 million in 1970. The population increased only seven percent during this period.

— There was a 22 percent increase in the number of x-ray examinations performed, from 174 million in 1964 to 212 million in 1970.

— There was a 30 percent increase in the number of films exposed, from 506 million in 1964 to 661 million in 1970.

— The average number of films per radiographic examination increased from 2.2 in 1964 to 2.4 in 1970.

TABLE 3.1 TRENDS IN RADIOGRAPHIC DIAGNOSTICS

PERSONS X-RAYED	1964	108 MILLION
	1970	130 MILLION
X-RAY EXAMINATIONS	1964	173 MILLION
	1970	212 MILLION
FILMS EXPOSED	1964	506 MILLION
	1970	661 MILLION

These trends have probably continued since 1970, especially the increase in film usage.

In 1971 the National Conference of Radiation Control Program Directors initiated the Nationwide Evaluation of X-Ray Trends (NEXT) to assess patient exposure from specific routine radiographic examinations. Analysis of data from this program indicates that the weighted mean exposure for nine of the 12 radiographic projections surveyed increased between 1973 and 1975.[3]

Among the scientific bodies who have reviewed diagnostic exposure issues is the Biological Effects of Ionizing Radiation (BEIR) Committee of the National Academy of Sciences. In its 1972 report, the Committee concluded that as much as 30 percent of patient exposure is due to the use of less than optimal techniques, and that nearly ten percent of all exposure can be attributed to retake examinations. The Committee further expressed the view that "medical radiation exposure can and should be reduced considerably by limiting its use to clinically indicated procedures utilizing efficient exposure techniques and optimal operation of radiation equipment. Consideration should be given to the following:

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[1] *The Effects on Population of Exposure to Low Levels of Ionizing Radiation (BEIR Report).* National Academy of Sciences—National Research Council (November 1972), p. 50.

[2] "Population Exposure to X-Rays." BRH:FDA 73-8047 (November 1973).

[3] "National Evaluation of X-Ray Trends." BRH:FDA 76-8052 (1976). HEW (FDA) 78-8056.

1. Restriction of the use of radiation for public health survey purposes, unless there is a reasonable probability of significant detection of disease.

2. Inspection and licensing of radiation and ancillary equipment.

3. Appropriate training and certification of involved personnel. Gonad shielding (especially shielding the testes) is strongly recommended as a simple and highly efficient way to reduce the Genetically Significant Dose."

The Report also stated "that experts estimate that it appears reasonable that as much as a 50 percent reduction in the genetically significant dose (GSD) from medical radiology might be possible through improved technical and educational methods."[4] A study[5] by FDA's Bureau of Radiological Health (BRH) indicates that in 1970 the genetically significant dose was approximately 20 millirems per American; using the BEIR risk estimate, this could cause up to 543 serious health effects (genetically related). It appears that half of these, or 272, would be due to poor radiological practice.

Summary

Comprehensive Activities

The President approved recommendations which brought medical uses of radiation under specific Federal radiation protection guidance for the first time. The guidance was jointly recommended to the President by the EPA Administrator and the Surgeon General of the Public Health Service after careful consideration by affected Federal agencies.

A final BRH rule on procedures for exempting electronic products intended for U.S. government use from radiation safety performance standards was issued.

The Departments of the Army, Navy, and Air Force and the Indian Health Service agreed to participate in the mammography quality assurance program known as BENT (Breast Exposure: Nationwide Trends), at the invitation of BRH.

A National Academy of Sciences Committee completed an in-depth review of the present uses of ionizing radiation for the treatment of benign disease.

Diagnostic X-Ray Systems

A number of amendments were made to the BRH radiation safety performance standard for diagnostic x-ray systems; among them is one which will encourage the improvement of older systems by reducing the cost of upgrading them.

BRH was advised by one of its Advisory Committees to initiate development of recommendations for the proper application of mammography to various age groups of women.

Concerning personnel who work with diagnostic x-ray systems, BRH funded a followup of its pilot project to analyze factors affecting the performance of equipment operators, and cosponsored implementation of self assessment and competency assurance education program for technologists.

In the area of quality assurance and education, a quality assurance test kit is being evaluated by BRH; two new manuals are under development; a Diagnostic Radiology Quality Assurance Catalog was published; and a special program is being implemented in Public Health Service hospitals and clinics.

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[4] *BEIR Report*, p. 55.

[5] "Gonad Doses and Genetically Significant Dose from Diagnostic Radiology: U.S. 1964 and 1970." BRH:FDA 76-8034 (1976). GPO 017-015-00100-8, $1.30.

BRH awarded five more contracts to State radiation control agencies to inspect and gather test data on certified diagnostic x-ray equipment, bringing the number of States participating in the program to 22. The Bureau also informed manufacturers that it considered the industry's present rate of noncompliance with its standard unacceptable, and fined an x-ray assembler.

Among the relevant studies were an evaluation of somatic doses, skull x-ray selection criteria, development of an instrument to analyze neutron contamination, and problems of computed tomography scanners.

Nuclear Medicine

BRH is considering the development of safety performance standards and/or recommendations for ionizing radiation equipment used primarily for the treatment of cancer. Voluntary recommendations may be issued on the use of nuclear medicine techniques for the evaluation of diseases of the thyroid gland.

NRC proposed an amendment establishing specific guidelines for the calibration of teletherapy machines, and has changed its licensing policies to require that byproduct material licenses be issued to medical institutions rather than to the individual physicians using it.

Educational activities included workshops on radiopharmaceutical quality assurance, and *in vitro* nuclear medicine, as well as an examination of the NRC role in regulating the medical uses of radioisotopes. Radiological Physics Centers continued to provide primary physics services to hospitals, especially to approximately 300 who are part of the National Cancer Institute's Cancer Control Program.

Studies covered teletherapy calibration, thyroid imaging agents, possible delayed effects of therapeutic iodine-131, radiation and breast cancer, and repeat examinations in nuclear medicine.

Ultrasound

A U.S. patent was granted on a portable radiometer developed by BRH to measure the output of medical ultrasound therapy equipment, and a study was begun on the effects of fetal exposure to ultrasound in later life.

2. Executive Activities

a. Comprehensive Activities

Guidance

X-Rays in Federal Health Care Facilities

Editor's note:
While this report is generally confined to 1977 activities, it would be misleading not to mention that on January 26, 1978, the President approved recommendations which brought medical uses of diagnostic x-rays under specific Federal radiation protection guidance for the first time. The guidance, directed to Federal agencies, is designed to reduce exposure by eliminating clinically unnecessary uses and requiring that the best available techniques and equipment be used (43 F.R. 4377). It was jointly recommended to the President by the EPA Administrator and the Assistant Secretary for Health, HEW, after careful consideration by affected Federal agencies.

Developed under EPA's authority to advise the President on radiation matters which may affect health (formerly exercised by the now defunct Federal Radiation Council), the guidance applies to hospitals and clinics of the military services, the Public Health Service, and the Veterans Administration, among others. Minimizing exposure and maximizing the usefulness of diagnostic x-rays must be considered in both prescription and performance of x-ray examinations. For prescription, the guidance specifies that x-ray studies should be ordered only by licensable physicians—or in certain exceptional cases by others under their direct supervision—and that such studies should generally be used only for the purpose of obtaining diagnostic information. Most routine or screening examinations are prohibited unless they have been justified as yielding greater medical benefit than the radiation health risks and the costs involved. For example, many chest and lower back x-rays will not be performed, except on a case by case basis after a physician's examination, and mammography screening examinations for asymptomatic women under age fifty will not be performed unless justified.

Guides for the performance of examinations require that operators of equipment have demonstrated proficiency to obtain diagnostic radiographs with minimum exposure, that special consideration be given to pregnant or possibly pregnant patients, that protocols be established for inspection and maintenance of equipment and for quality control, and that appropriate shielding and collimation be used to protect patients. The recommendations also include numerical exposure guides for ten non-specialty x-ray examinations. Meeting these exposure guidelines and the equipment and technique goals is expected to reduce substantially the exposure received by patients for necessary diagnostic x-rays.

Exemption Procedures for Government-Used Electronic Products

A final BRH rule on procedures for exempting electronic products intended for U.S. government use from radiation safety performance standards was issued in the September 2 *Federal Register*. Its aim is to facilitate federal procurement or construction of needed electronic products that differ in design and application from those used by the general public.

An exempted product still will be required to meet the terms of the applicable federal performance standard to the extent appropriate for its intended application.*

Education and Quality Control

Participation in BENT

At the invitation of BRH, the Departments of the Army, Navy. and Air Force and the Indian Health Service agreed to participate in the mammography quality assurance program known as BENT (Breast Exposure: Nationwide Trends). BENT is an exposure and image quality assessment program designed to identify mammography facilities where the exposures appear unnecessarily high or unusually low for the type of image receptor being used. Clinical personnel at the facilities then are advised of corrections that can be made in procedures to reduce unproductive patient exposure and improve image quality.

Film Processor Conference

A conference funded by BRH addressed the problem associated with film processing in diagnostic radiology—a matter of concern because of the poor image quality and unproductive patient exposure that may result when diagnostic x-ray films are not properly developed. Some 70 invited specialists stressed the value of a daily quality control program for automatic radiographic film processors. Among the participants were representatives of the radiology, radiologic technology, and medical physics professions, industry, and government agencies.

National Radiation Control Network

BRH loaned equipment to FDA regional and State radiological health offices which lacked the facilities for playback of Bureau-produced videotape instructional programs. The equipment is part of a National Radiation Control Network, to be used for disseminating technical information for training purposes. In addition, if it is needed, the Network allows for rapid, uniform, national communication of information related to high priority radiation control problems.

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*This and much of the following information was provided by BRH in its Bulletins and Quarterly Reports.

Studies

Radiation Treatment of Benign Disease

A Committee of the National Academy of Sciences conducted a review for BRH, the results of which were published by the Bureau in November 1977 in a report titled "A Review of the Use of Ionizing Radiation for the Treatment of Benign Diseases" (HEW publication FDA 78-8043). The report identifies the major uses of ionizing radiation for therapy of benign conditions, describes the historical background relating to studies of the associated risks, presents current medical and radiobiological information pertinent to this subject, and summarizes the committee's recommendations.

Information from this report will be used by the Agency in preparing a *Federal Register* notice of intent to develop recommendations relating to the use of ionizing radiation for the treatment of benign diseases.

b. Diagnostic X-Ray Systems

Guidance

Amendments to X-Ray Standard

In the November 8, 1977 *Federal Register*, BRH issued an amendment to the radiation safety performance standard for diagnostic x-ray systems, which is designed to encourage the improvement of older systems by reducing the cost of upgrading them. The amendment permits the installation of certified beam-limiting devices that do not provide positive beam limitation on stationary general purpose x-ray systems containing certain uncertified components. The standard originally required that, whenever a certified beam limiting device was installed on a stationary general purpose system, the device had to provide postive beam limitation—regardless of whether the system contained any certified components.

Five other amendments to the x-ray standard were published in the September 2, 1977 *Federal Register*; they would (1) change the applicability of the standard to include image receptor supports for mammographic systems and add a definition of these components, (2) establish a limit on the transmission of the x-ray beam through the image receptor support on mammographic systems, (3) revise the x-ray beam through the image receptor support on mammographic systems, (4) revise the x-ray field limitation and alignment requirements for mammographic systems and attachments, (5) allow alternative ways of limiting and aligning the x-ray field for certain special purpose x-ray systems, and (6) modify the test method for measuring exposure reproducibility.

Earlier in the year, in the February 25, 1977 *Federal Register*, amendments were published in the final form to revise the list of major components to which the standard applies; to add alternative certification and labeling procedures for products marketed as a combination of two or more components; to strengthen the requirements for fluoroscopic x-ray high-level controls; and to clarify several definitions, performance requirements and methods for determining compliance.

Recommendations on Diagnostic Radiology Doses

In response to a resolution by its Medical Radiation Advisory Committee, BRH is planning a study of the feasibility of developing recommendations concerning ranges of skin exposure or other organ doses per exposure for diagnostic radiology. The issues were discussed in detail by the Subcommittee on the Division of Training and Medical Applications, which examined some proposed questions and offered several suggestions regarding their scope. In the dental x-ray area the BRH has already found it advantageous to develop recommended exposure ranges for various techniques. In mammography quality assurance, exposure ranges for various image receptor systems have also evolved. They have found it useful in determining when patient exposure is excessive and radiographic quality less than optimal. It is felt that similar efforts may be useful for other medical x-ray procedures.

Mammography Recommendations Suggested

The BRH Medical Radiation Advisory Committee advised the Bureau to initiate development of recommendations for the proper application of mammography to various age groups of women and publish a *Federal Register* notice to that effect. Although the technique has been in use for a number of years, controversy concerning its efficacy as a screening tool for the detection of breast cancer in asymptomatic women under 50 has not been resolved.

Education and Quality Assurance

Medical X-Ray Operator Job Performance

BRH is funding a followup of its pilot project to analyze the background and environmental factors affecting the performance of medical x-ray equipment operators. The pilot project, also conducted under contract, included the design and testing of a methodology for obtaining information from x-ray equipment operators in hospitals, clinics and private offices in the Baltimore-Washington-Richmond area. The followup study will provide information on a more representative sample of x-ray operators, and will include direct measurements of on-the-job performance.

Radiologic Technologists Self Assessment

Along with the Bureau of Health Manpower of the Health Resources Administration, BRH is sponsoring nationwide implementation of a self assessment and competency assurance education program for technologists working in the field of diagnostic radiology. The American Society of Radiologic Technologists (ASRT) is under contract to review and revise a test developed earlier, and administer it to volunteer practitioners. Based on the results, ASRT will prepare national, regional, and individual profiles of practitioner strengths and weaknesses.

ASRT also will develop educational packages that address the needs identified in the profile, design a program for making the packages available, and develop a plan for integrating the packages with or relating them to current education in diagnostic radiologic technology, such as the ASRT's Evidence of Continuing Education Program.

New X-Ray Quality Assurance Materials

BRH has continued its efforts to provide readily available information on techniques for effective quality assurance programs in diagnostic radiology. A two volume manual on processing quality assurance techniques was distributed widely and a contract has been awarded to the University of Colorado to develop two additional manuals. The new manuals, one for radiographic and fluoroscopic x-ray units and the other for image intensifiers and assorted equipment, will describe a set of effective tests which can be conducted to monitor the performance of this equipment.

The development of the manuals is only part of the BRH effort to provide assistance to diagnostic radiology facilities seeking to establish or improve a quality assurance program. The BRH also published a Diagnostic Radiology Quality Assurance Catalog to provide a list of quality assurance devices, training, services, and publications available to facilities.

Cooperative programs with professional organizations are intended to provide further assistance to facilities. For example, BRH supported the Task Group of the Diagnostic Radiology Committee of the American Association of Physicists in Medicine in the efforts which climaxed with publication of a manual entitled "Basic Quality Control in Diagnostic Radiology." BRH is currently conducting a field evaluation test of the American College of Radiology Quality Assurance kit. Other cooperative programs have been conducted with government medical facilities. The BRH has assisted several Public Health Service hospitals in establishing quality assurance programs and will be providing similar assistance to Indian Health Service medical facilities.

Breast Exposure: Nationwide Trends (BENT) Training

BRH conducted training sessions in mammographic quality assurance and provided State radiation control agencies with dosimeters as part of its effort to make the BENT program available on a nationwide basis. (As noted above, BENT is a state-based exposure and image quality assessment program designed to assist radiological health officials in identifying mammography facilities whose exposures appear unnecessarily high or unusually low for the type of image receptor being used, and then correcting such situations through consultations with practitioners.)

X-Ray Film/Screen Imaging Characteristics

BRH initiated an automated system for measuring the characteristics of the many commercially available combinations of x-ray films and image-intensifying screens. (Screens result in less patient exposure because they provide higher efficiency of x-ray detection than film alone). The automated system is designed to simplify the task of making repeated measurements on the numerous possible combinations of films and screens. It will be used to generate data for a handbook, which will be distributed to users and manufacturers to permit intercomparison of film/screen properties.

A new generation of rare earth phosphors—offering a significantly higher radiation utilization rate than conventional screens—has been introduced. The dose-reduction potential of these screens, however, is not presently being realized. This is because of confusion from the diversity of film/screen systems on the market and the wide disparity of information concerning their use. The handbook is intended to allow comparison of present-day systems, provide guidance for their proper use, and point the way to future improvements in film/screen technology.

Workshops on Scintillation Camera Quality Control

BRH is collaborating with the Technologist Section of the Society of Nuclear Medicine to continue the promotion, arrangement, and presentation of workshops for quality control of scintillation cameras. They will increase opportunities for training in quality control procedures, ultimately reducing unnecessary exposures to patients undergoing diagnostic nuclear medicine examinations.

Compliance

State Contract for X-Ray Compliance

BRH awarded five more contracts to State radiation control agencies to inspect and gather test data on certified diagnostic x-ray equipment, bringing the number of States participating in the program to 22. In addition to the compliance inspections, ten of the 22 contract States will collect data on image receptors and automatic film processors for use in BRH's effort to identify specific areas that should be addressed by quality assurance programs. Eight States will also gather data on radiographic units equipped with automatic exposure control systems to provide information that can be used in evaluating the performance of these devices.

Manufacturers' Noncompliance Problem

Over the past three years, BRH's field tests of new medical and dental diagnostic x-ray equipment have indicated a high rate of noncompliance with the federal performance standard. The test data show the noncompliances are caused by improper equipment design, inadequate factory quality control and testing programs, and/or improper assembly of components. Although only about 15 percent of all certified x-ray machines have been tested to date, the trend has been a matter of growing concern because of the probability of a similar noncompliance rate in the certified units that have not yet been tested.

In August 1977, BRH wrote to manufactuers, informing them of the problem and the need for remedial action. The letter stated that the Agency considered the industry's present rate of noncompliance unacceptable. It emphasized that manufacturers will be responsible for correcting any noncompliances found in the future through BRH's testing program. Manufacturers were advised to take steps to assure that all previously installed products comply with the standard and to inform the BRH of any actions taken to reduce and eventually eliminate future cases of noncompliance. The letter also indicated that BRH would continue to analyze the field test data and initiate enforcement actions, as appropriate.

Compliance Test Manual Revised

The Manual on "BRH Routine Compliance Testing for Diagnostic X-Ray Systems" has been revised and reissued. Copies were distributed to all State radiation control agencies, members of the Conference of Radiation Control Program Directors, as well as FDA Regional Radiological Health Representatives, Radiation Control Officers, and Consumer Safety Officers. The new edition replaces the version published and distributed in 1975. Intended primarily for use by State and Federal personnel responsible for enforcing the Federal diagnostic x-ray performance standard, the manual describes the test procedures and equipment to be used in screening certified x-ray systems for evidence of compliance.

X-Ray Assembler Fine

A dental supply corporation in Pittsburgh, Pennsylvania, and two of its employees, the Branch Manager and Service Manager, signed a consent decree to pay $10,000 fine for failure to certify and report the assembly of diagnostic x-ray systems, as required by the federal diagnostic x-ray performance standard.

The civil penalty was recommended by FDA's Philadelphia District Office and the Agency after an investigation revealed numerous incidents in which the firm had violated the standard.

This is the second time a civil penalty has been levied for failure to comply with the reporting requirements of the x-ray standard. In December 1976, another Pennsylvania firm engaged in the assembly of diagnostic x-ray equipment was fined $2,000 for two incidents of failure to submit the required reports.

Studies

Evaluation of Somatic Doses

Under a BRH contract, an investigator at Dickinson College in Carlisle, Pennsylvania has begun to evaluate the impact of somatic doses from diagnostic radiology procedures. The project will combine a previously developed Agency method for computing organ doses with data on medical practice to determine the relative somatic health impact of diagnostic x-ray procedures. The data will be used to: (1) expand the present knowledge of the variation in somatic doses for x-ray examinations, based on observed variations in x-ray techniques; (2) identify the most significant x-ray examinations from the standpoint of somatic dose to an individual or population; and (3) convert the technical considerations affecting somatic doses from x-ray examinations into practical information for dissemination to patients and medical practitioners.

Skull X-Ray Selection Criteria

A BRH-sponsored study of the use of specified patient selection criteria for ordering skull x-rays in trauma cases was begun at a second medical facility. The first study, conducted at the University of Washington Hospital in Seattle, demonstrated that when skull x-rays were performed only on patients exhibiting specific symptoms, there was a 40 percent reduction in emergency department skull radiography with no adverse effects on patient care.

The second study will be conducted at the Harborview Medical Center in Seattle. This hospital has had no formal policy for guiding physicians on this matter and it served as a control in the first study. The results showed that skull radiography at the University of Washington Hospital decreased by 40 percent following implementation of the policy, while skull radiography at the Harborview Medical Center increased by 64 percent during the same time period.

It is expected that study results will provide an indication of whether this policy should be recommended for all medical facilities nationwide.

Instrument to Analyze Neutron Contamination

BRH's Division of Electronic Products worked on developing a portable instrument for assessing the neutron component of x-ray therapy beams from high energy medical linear accelerators (linacs). Although such accelerators are designed to produce high-energy x-rays for tumor irradiation, they also produce neutrons. Neutrons contamination is of concern for two reasons. First, neutrons may contribute a significant whole body dose of a patient undergoing therapy. Second, even though the neutron dose may be small compared to the prescribed dose, its biological effect can be several times greater. The significance of the new instrument is that it will be portable, providing a way to measure neutron spectra and dose rates under actual clinical conditions.

Problems of Computed Tomography Scanners

BRH's Task Force on Computed Tomography (CT) and its working groups were active in three primary areas in 1977. First, they investigated the fundamental problem of making uniform, meaningful measurements of radiation dose. Second, they worked toward correcting inadequacies and inconsistencies in the diagnostic x-ray standard as it applies to CT systems. A document outlining the conceptual bases for possible future amendments has been drafted and circulated to users and manufacturers for preliminary comment. The third area of activity is an attempt to define CT performance and use problems and to determine current practices in quality assurance and training.

c. Nuclear Medicine

Guidance

Safety Program for Radiation Therapy Equipment

BRH is considering the development of safety performance standards and/or recommendations for ionizing radiation equipment used primarily tor the treatment of cancer. A notice in the March 22 *Federal Register* announced the Agency's plans to take steps to assure the safe and effective use of this equipment and invited interested persons to submit opinions on the appropriate course of action.

Nuclear Medicine Thyroid Study Techniques

Partly as a result of a new task force report, "The Developing Role of Short-Lived Radionuclides in Nuclear Medicine," BRH is considering the issuance of voluntary recommendations on the use of nuclear medicine techniques for the evaluation of diseases of the thyroid gland. The report summarized the history of the development and use of short-lived accelerator-produced radionuclides, and provides specific recommendations on techniques that lower radiation dose in thyroid studies without compromising clinical information. Comments were invited in the October 18, 1977 *Federal Register* regarding recommendations which would specify the diagnostic procedures where radioiodine should not be used, as well as the conditions where it is most appropriate. The recommendations would also describe circumstances where technetium-99m is a suitable substitute for iodine-123, or iodine-133, and suggest appropriate instrumentation and dosages for each radiopharmaceutical.

Teletherapy Machines

Therapeutic techniques include the use of radioactive drugs internally (for example, in the treatment of thyroid cancer), the use of radioactive devices both as implants and on the surface of the body (termed "brachytherapy," or "therapy from a short distance") and the use of radioactive devices external to the body (termed "teletherapy," or "therapy from a distance").

A proposed amendment to 10 CFR 35.13, issued May 19, 1977, establishes specific guidelines for the calibration of teletherapy machines. The NRC staff worked closely with the American Association of Physicists in Medicine in developing the technical requirements in the rule. It would require teletherapy licensees to:

- Have a qualified expert perform full calibration measurements on each teletherapy unit at least once each year.
- Perform spot-check measurements on the output of their units at least monthly.
- Report to the NRC any radiation doses that differ from prescribed doses by more than 10 percent.

The proposed amendment is designed to ensure that patients receive correct radiation doses.

Licensing

On August 15, 1977, 10 CFR 35.12 was amended to require that NRC issue byproduct material licenses to medical institutions rather than to the individual physicians using the material. This rule will clearly place the responsibility for radiation safety with the institution and eliminate the disruption of medical service which can occur when a physician holding a private practice license leaves an institution. It will also simplify NRC's regulatory efforts by confining responsibility to the hospital and eliminating the extra cost of maintaining multiple licenses at the same institution.

Education and Quality Assurance

Workshops on Radiopharmaceutical Quality Assurance

BRH is presenting a series of workshops for nuclear medicine technologists on "Radionuclide Handling and Radiopharmaceutical Quality Assurance." The workshops are being held in selected locations as a preliminary step to promoting them nationwide.

Course materials for the one-day workshops were developed by the University of Colorado under an FDA contract. The lectures cover radionuclide generators, quality control tests for radiopharmaceuticals and dose calibration equipment, handling of xenon isotopes, and radiation safety in the laboratory. The laboratory sessions are designed to give "hands-on" experience in each of these areas.

In Vitro Nuclear Medicine Workshops

BRH awarded a contract to the University of Tennessee for the development of training materials for a "Quality Control for *In Vitro* Nuclear Medicine Procedures Workshops." Areas to be covered include the history and background of *in vitro* tests, the extent and potential of these tests, establishment of normal values and ranges, quality control of appropriate counting systems and ancillary equipment, new product evaluation, and radiation safety in wet laboratory procedures.

NRC Role in Medical Uses Of Radioisotopes

In May 1977, the NRC held meetings both with the public and with its Advisory Committee on the Medical Use of Isotopes to consider the extent to which the NRC should be involved in regulating the medical uses of radioisotopes. Approximately 90 members of the public attended these two meetings. The 34 oral and written comments received will be considered by the NRC staff in the preparation of a comprehensive policy statement on this matter.

Radiological Physics Centers

Six Radiological Physics Centers across the country continued to provide primary physics services to hospitals, especially to approximately 300 who are part of the National Cancer Institute's Cancer Control Program. As their major emphases, the Centers provide calibration sevices, review physics protocols for various activities, and seek ways to reduce radiation dose in diagnostic procedures.

Studies

Teletherapy Calibration Study

Under an interagency agreement between BRH and the National Bureau of Standards, a study of cobalt-60 teletherapy units in medical facilities was extended. The first phase, completed in spring 1977, was designed to survey the approximately 1,000 U.S. facilities licensed to administer therapy with cobalt-60 sources. Dosimeters were used to evaluate the variation between a specified dose and the dose actually delivered. In the followup study, selected facilities were resurveyed, especially those whose dosimeter readings differed substantially from the specified value.

Thyroid Imaging Agents Studies

BRH initiated a contract with the Michael Reese Medical Center, Chicago, Illinois to conduct a comparative study of the efficacy of iodine-123 as sodium iodide and technetium-99m as sodium pertechnetate for thyroid imaging. Diagnostic uncertainty results from apparent discrepancies noted in the ability of thyroid nodules to concentrate these two agents.

Possible Delayed Effects of Therapeutic Iodine-131

BRH awarded a contract to the Mayo Clinic to conduct a followup study of persons treated for hyperthyroidism with therapeutic doses of radioactive iodine-131 surgery. Iodine-131 is now considered the treatment of choice in most U.S. hospitals for hyperthyroidism. However, the possibility exists that persons exposed to therapeutic levels of iodine-131 in the past may develop adverse health effects after a latent period of many years. Most studies to date have not demonstrated a connection between exposure to iodine-131 and delayed effects, but the sample sizes have been too small or the followup period too short to provide definitive information.

Radiation and Breast Cancer

The National Cancer Institute refined the estimation of breast doses and breast cancer risk, by following up women exposed to multiple fluoroscopic chest examinations. The analysis reaffirmed that repeated relatively low radiation doses pose some future risk of breast cancer, that the risk may be cumulative, and that multiple radiation doses may convey the same breast cancer risk as a single exposure of the same total dose. Also, a recent analysis has suggested that proliferating breast tissue is especially sensitive to the carcinogenic effects of ionizing radiation. A case study of breast cancer following radiotherapy (for metastatic Wilms' tumor) suggested that genetic factors may predispose individuals to radiogenic cancer. In a related project, the Institute launched a collaborative effort with the Harvard School of Public Health to evaluate the risk of cancer among patients treated with large doses of radiation for cervical cancer.

Repeat Examinations in Nuclear Medicine

Under contract between BRH and the Small Business Administration in Dallas, Texas, a retrospective survey was begun of repeat examinations in nuclear medicine performed in two hospitals. The survey will be limited to *in vivo* nuclear medicine procedures and will provide data on the frequency and types of procedures performed. The resulting information will be used to determine the causes of repeated procedures and to formulate ways of reducing their frequency.

d. Ultrasound

Education and Quality Assurance

Ultrasound Therapy Measurement Device

A U.S. patent was granted on a portable radiometer developed by BRH to measure the output of medical ultrasound therapy equipment. It was devised to fill the need for a portable instrument that could be used in the field to determine the ultrasonic power emitted by therapeutic units, and provides a previously unavailable capability for accurately calibrating the output of such units once they are in use in medical facilities.

Studies

Fetal Exposure to Ultrasound

BRH contracted with the University of Colorado to perform a study to determine whether children at 8 to 10 years of age who were exposed to diagnostic ultrasound *in utero* are different with respect to general health, growth, physical, and intellectual development, and neurological function as compared to an unexposed but otherwise similar group of children.

IV. NUCLEAR POWER

1. Introduction

Nuclear power is by far the most controversial source of manmade radiation. While it accounts for only a small percentage of the average American's exposure, nearly all scientists agree that any dose of radiation from any source may involve some degree of risk, and that it is prudent for radiation protection purposes to assume that it does. The long term environmental burden must be considered as well as the risks to individuals, since many radioactive substances have half-lives of hundreds or thousands of years.

The basic controversy is how much risk people are willing to assume — for themselves, the world environment, and future populations — to gain the benefits of nuclear power. There is widespread and violent disagreement about nearly all the factors in the risk/benefit equation: what the effects of low level radiation are, how much nuclear power will cost relative to the alternatives in ten years, what the danger of an accident is, if and how wastes can be contained for millennia, and so on almost *ad infinitum.*

Emissions from nuclear power plants can be reduced to virtually any level with appropriate controls — but the costs of each increment of reduction must be weighed against preventing risks whose significance is still in debate. The above considerations alone would make policy decisions complex and difficult; a further complication is the threat of nuclear proliferation, particularly when combined with the possibility of terrorist diversion of nuclear materials.

This chapter deals only with the radiation protection aspect of these issues, including limited material on preventing accidents whose aftermath would require protection activities.

a. Industry Status

As background to that discussion, the status of the nuclear power industry in 1977 is described partially by Figure 4.1, showing that, for the third straight year, orders for new reactors were dramatically below the expected numbers.

As of September 30, 1977, there were 230 nuclear power units either in operation, being built or being planned, representing a total capacity of 230,000 net megawatts electric (MWe). Of these 230 units, 202 had entered the NRC licensing process, as follows:

- 65 licensed to operate, with a total capacity of 47,000 MWe.

- 78 with construction permits, representing 83,000 MWe capacity.

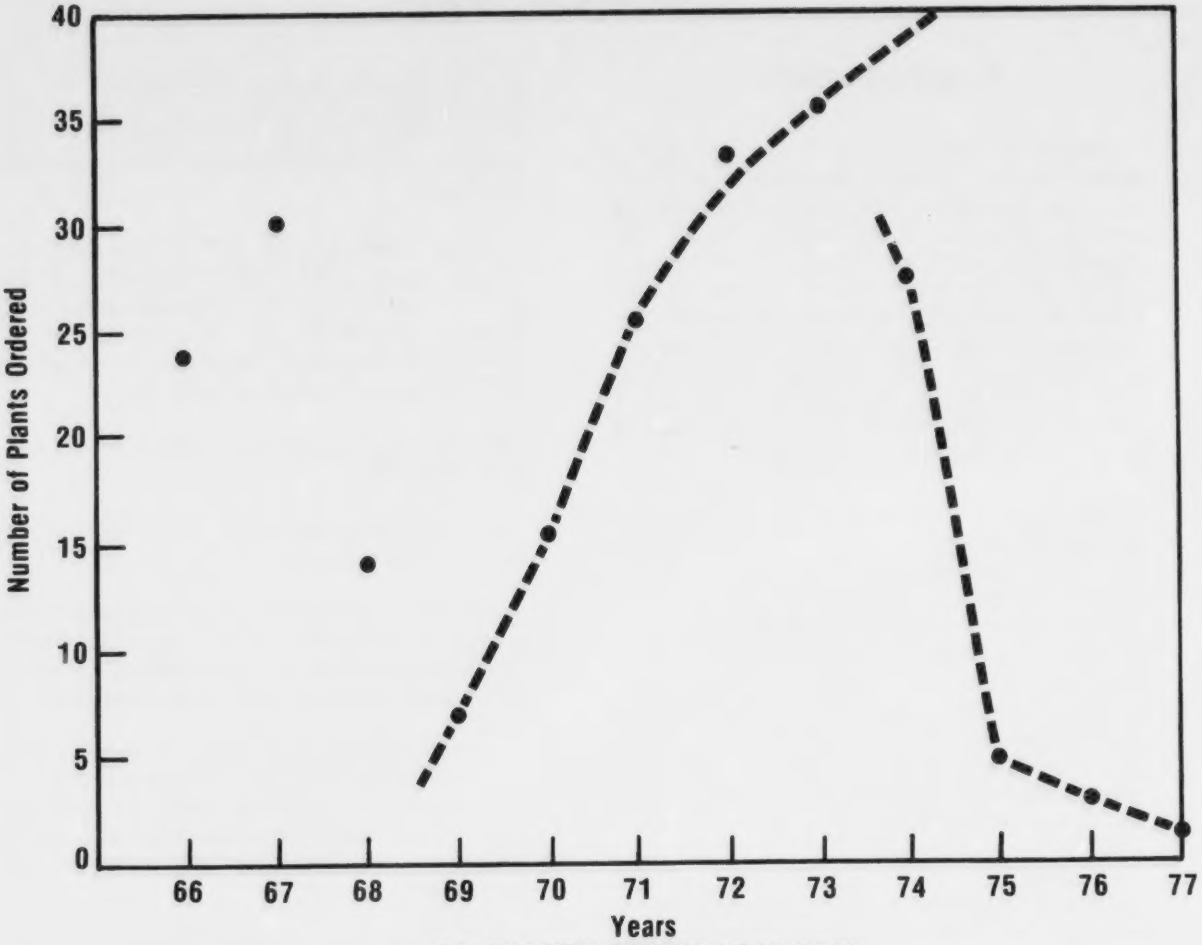
- 59 under review for construction permits, representing 66,000 MWe capacity. (Initial construction work was proceeding on 15 of these under limited work authorizations.)

Of the remaining 28 units — those which had not entered the NRC licensing process — 13 had been ordered and 15 publicly announced. These and other NRC data below were extracted from the NRC annual report for FY 1977.

b. Presidential Action

In 1976 EPA was asked to participate in a Nuclear Policy Review under President Ford, and continued its participation when an Ad Hoc Group on Non-Proliferation was established early in 1977 under the National Security Council to review current U.S. policies. The Group, along with others both inside and outside government, reported its findings during the year. On April 7, 1977, President Carter announced his nuclear energy policy, in which the foremost consideration is nonproliferation of nuclear weapons. This policy statement included decisions to defer indefinitely the commercial reprocessing and recycling of plutonium in the U.S., to accelerate research into alternative nuclear

Figure 4.1



U.S. REACTOR ORDERS EACH YEAR

fuel cycles, to restructure the breeder program, and to increase U.S. enrichment capacity. It also included decisions on a number of activities related to the import and export of nuclear facilities, materials and equipment. Similar messages were conveyed in President Carter's Energy Address to Congress on April 20, 1977, and his Message to Congress of April 27, 1977, which transmitted a draft Nuclear Non-Proliferation Policy Act.

Among the President's specific energy policy proposals was that an International Nuclear Fuel Cycle Evaluation be undertaken. It is now underway in 45 countries, with the International Atomic Energy Agency serving as Secretariat. As a major part of the U.S. contribution, the Department of Energy established a Non-Proliferation Alternative Systems Assessment Program to evaluate alternative nuclear energy systems and to devise a system for assessing their proliferation potential.

EPA's representation in the Ad Hoc Group on Non-Proliferation has been effective in seeing that concern for the environment was not overlooked while that Group and the other efforts were focusing on potential areas of conflict between non-proliferation and domestic and foreign energy needs. Under the Ad Hoc Group, EPA is, in addition, a participant at the technical level, in the Working Group on Spent Fuel Disposition and the Interagency Group on LDC Energy Cooperation. The International Nuclear Fuel Cycle Evaluation also has eight working groups, with EPA participating in the U.S. support working groups on spent fuel management, waste management and disposal, and advanced fuel cycle concepts. It may be viewed as a measure of success that appropriate concern for the environment was included in the Nuclear Non-Proliferation Act which passed the House of Representatives in 1977 and became law early in 1978.

2. Selected Major Judicial Activities

Uranium Fuel Rule

Natural Resources Defense Council, Inc., et al. v. NRC, et al. (D.C. Cir., Nos. 74-1385, 74-1586).

Vermont Yankee Nuclear Power Corp. v. NRDC (Sup. Ct., No. 76-149).

Baltimore Gas & Electric Company, et al. v. NRDC, et al. (Sup., Ct., No. 76-653).

The Court of Appeals for the District of Columbia Circuit, by its July 21, 1976 decision in this consolidated case, set aside the waste management and reprocessing portions of the Commission's uranium fuel cycle rule ("Table S-3"). That rule had assigned numerical limits to the environmental effects acceptable as a consequence of the licensing of a nuclear power plant and was intended, for purposes of making an environmental assessment under NEPA, to quantify the additional environmental impact of licensing a particular reactor, insofar as the fuel cycle was concerned. Without Table S-3 in place, the Commission's analysis of the environmental effects of the proposed Vermont Yankee plant was found to be inadequate, and the Vermont Yankee operating license was remanded to the Commission for further consideration pending an adequate assessment of the fuel cycle issues. On February 22, 1977, the Supreme Court granted Vermont Yankee's certiorari petition and consolidated it with the *Aeschliman* case, discussed below. The Supreme Court has decided to hold the *Baltimore Gas* case in abeyance pending its decision in *Vermont Yankee.*

Energy Conservation Issues

Nelson Aeschliman, et al. v. AEC, et al. (D.C. Cir., No. 73-1776).

Saginaw Valley Nuclear Study Group, et al. v. AEC, et al. (D.C. Cir., No. 73-1867).

Consumers Power Company v. Nelson Aeschliman, et al. (Sup. Ct., No. 76-528).

On review of the construction permits issued for Consumer Power Company's Midland (Michigan) facility, the Court of Appeals for the District of Columbia Circuit disapproved the Commission's treatment of energy conservation issues, ruling that the Commission had placed too stringent an evidentiary burden on groups seeking Commission consideration of energy conservation issues. The court also held that Advisory Committee on Reactor Safeguards (ACRS) reports must be sufficiently explicit to inform the public of all identified hazards of reactor operation and that licensing boards have the obligation to return cryptic reports to the ACRS for further elaboration. The court remanded the case to the Commission for the purpose of restriking the NEPA cost/benefit balance, including an assessment of unaddressed fuel cycle issues. On February 22, 1977, the Supreme Court granted certiorari and consolidated this case with the *Vermont Yankee* fuel cycle case. These cases were argued on November 28, 1977.

Transportation Litigation

New York State filed suit against the NRC and six other Federal agencies in the Federal District Court of New York City in May 1975 to ban transportation by air, and related connecting transportation, of plutonium and other special nuclear materials to, from, in and over the City and State of New York and the United States and its territories. In September 1975 the district court denied a motion for a preliminary injunction, which was sustained on appeal to the Second Circuit Court of Appeals. The disposition of the case awaits consideration of the NRC environmental statement (NUREG-0170) issued in December 1977. (In the meantime, air transportation of plutonium is stayed by Public Law 94-79.)

New York City passed a health ordinance in September 1975 which requires city approval for the transportation of certain types and amounts of radioactive material within its borders. The NRC presented testimony at hearings on this matter in opposition to the ordinance and the Justice Department challenged the legality of the action in a suit against the City of New York. In January 1976, the district court denied a motion by the U.S. Attorney for a preliminary injunction against the virtual ban on transportation through the city. The Secretary of Transportation is considering the compatibility of the ordinance with Federal regulations. A public hearing on this matter was held by the Department of Transportation in New York during November 1977.

Several proceedings on rail transportation of spent fuel and radioactive wastes were initiated before the Interstate Commerce Commmission (ICC) in which railroad organizations have proposed tariffs that would severely restrict such transportation. The NRC entered a contention that, insofar as the proceedings involve issues of radiological safety in the transportation of radioactive materials, those concerns should be addressed to the NRC and/or the DOT and not to the ICC. The ICC issued an environmental impact statement on these matters in August 1977. NRC provided some technical assistance to ICC in this task. The ICC Administrative Law Judge then ruled that the risks of transport were not great enough to justify certain railroads' refusal to carry spent nuclear fuel as common carriers. The ICC later decided in favor of the position that radioactive material transportation safety issues should be left to NRC and DOT. The railroad organizations have requested that the full ICC review the matter.

Constitutionality of the Price-Anderson Act

On March 31, 1977, the U.S. District Court for the Western District of North Carolina issued a memorandum of decision declaring that the Price-Anderson Act's provision limiting liability from a nuclear plant accident to $560 million was unconstitutional. This decision generally supported the position of the plaintiffs, the Carolina Environmental

Study Group, Inc. and its individual members. The NRC and Duke Power Company, who are co-defendants in this case, have both filed notices of appeal to the U.S. Supreme Court. In November 1977, the Supreme Court indicated it would review the decision.

Wastes

Natural Resources Defense Council, Inc., v. *NRC* (2d Cir., No. 77-4157).

On August 25, 1977, the Natural Resources Defense Council filed a petition to review the Commission order denying NRDC's request that a rule-making proceeding be initiated to determine whether radioactive wastes generated in nuclear reactors can be safely disposed of and to suspend licensing of plants pending such a determination. The case was pending before the Second Circuit at the close of the report period.

North Anna Plant

Virginia Electric and Power Company v. *NRC* (4th Cir., No. 76-2215).

North Anna Environmental Coalition v. *NRC* (4th Cir., No. 76-2331).

VEPCO and the North Anna Environmental Coalition petitioned the Fourth Circuit to review the Commission's North Anna opinion, which imposed a $32,500 fine on the utility for false statements concerning geologic faulting at the site.

The Fourth Circuit consolidated the cases and permitted the Commonwealth of Virginia to intervene. Basically, NRC argues that the $32,500 civil penalty assessed against VEPCO was proper; that an intent to deceive is not a necessary element of an actionable false statement; that the materiality of the statement must be judged from the point of view of an NRC employee reviewing the utility's application for a power plant license, not the lay public's understanding; and that omission of information can constitute a false statement. The case was argued on December 6, 1977 and was awaiting decision at the end of 1977.

3. Summary

President Carter's announced nuclear energy policy, in which the foremost consideration is non-proliferation of nuclear weapons, caused several new decisions concerning reprocessing and other matters.

A few of the major judicial areas addressed were the uranium fuel cycle rule, energy conservation issues, transportation, the Price-Anderson Act, wastes, and the North Anna plant.

Comprehensive

EPA/ORP continued to evaluate the environmental impact of carbon-14 discharges from normal operations of the uranium fuel cycle facilities, with a view to a possible amendment of current regulations.

NRC staff proceeded with development of radiological effluent Standard Technical Specifications to meet the requirements of the as low as practicable rule. They also began to work out the details of implementing the EPA uranium fuel cycle standard.

EPA/ORP continued to question the ERDA sponsored Reactor Safety Study's treatment of health effects following a reactor accident.

Among the more important Environmental Impact Statements dealt with during the year were those on mixed oxide fuel, expansion of the Portsmouth Gaseous Diffusion Plant, and Floating Nuclear Power Plants.

EPA/ORP conducted a number of relevant studies, including its operational analysis program, a report on gaseous effluents from reactors, and radiation studies at nuclear facilities, as well as a review of liver cancer risk due to certain actinide radionuclides. NRC studies and reviews included environmental dispersion, ecological impact, and socioeconomic and regional fields. DOE also covered a wide spectrum of concerns, including programs to investigate the potential of the nuclear fuel cycles for contaminating the environment and to analyze environmental control systems, in addition to research on mechanisms to radiation interaction with living cells.

Wastes

EPA/ORP launched its effort to develop criteria expressing the basic philosophy that should pervade all agencies' waste standards, by holding two open public workshops. Three ongoing contracts were initiated as part of developing the high level waste standard the President directed EPA to issue in 1978.

NRC worked on a revision to a Guide on the design of storage facilities at reactors, waste classification criteria, proposed regulations regarding high level waste repositories, performance criteria for solidified reprocessing wastes, and technical studies of decontamination and decommissioning of nuclear installations. Low level wastes were also the focus of a number of programs, including standards and criteria development and an examination of alternatives to shallow land burial.

EPA/ORP reviewed NRC's responses to the comments EPA submitted on the Commission's "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," and a number of Environmental Impact Statements covering waste management operations at Savannah River Plant, Oak Ridge intermediate wastes, Brookhaven National Laboratory, and waste management operations at Idaho National Laboratory.

EPA/ORP also worked to determine the impact of ground disposal of wastes by conducting studies at operating commercial burial studies; specific programs include one to characterize reactor-generated low level radwastes and an inventory and projections of low level radwastes for burial at commercial facilities. "Radiological Measurements at the Maxey Flats Radioactive Waste Burial Site—1974 to 1975" was published in January 1977.

NRC began a special study on the adequacy of high-level waste storage at West Valley, New York.

In support of its efforts to develop standards for high level radioactive waste management, EPA initiated a contract to evaluate the adequacy of the state of knowledge in the earth sciences for estimating the environmental impacts from deep geological disposal.

Spent Fuel

NRC completed a draft environmental statement on spent fuel for internal review, concluding that no modification of current regulations summarizing environmental considerations for the uranium fuel cycle appears necessary.

Transportation

NRC issued a report defining regulatory and other responsibilities of different parties involved in dealing with transportation accidents involving radioactive materials. In collaboration with the Department of Transportation, a study was begun on the adequacy of existing requirements for the shipment of material containing a low level of radioactivity. A draft environmental statement was prepared to assess the impacts associated with transportation of all radioactive materials. EPA/ORP reviewed a more specialized, DOE sponsored report on transoceanic shipping of spent fuel and plutonium.

Abnormal occurrences numbered 19 in 1977, according to NRC's major interim criteria defining them.

Emergency Response Planning

EPA continued development of its manual for state and local governments on Protective

Action Guides and protective actions for nuclear incidents. Protective Action Guides have been developed for three accident phases, each requiring a different type of response. Guidance on instrumentation for radiological emergencies was developed by an Interagency Task Force, and other interagency activities were also initiated. DOE expanded its computer technique to project dose on the basis of environmental data collected following a release. Both EPA and NRC participated in an international effort to develop guidance on response plans for major radiological accidents.

4. Executive Activities

Comprehensive Activities

Guidance

EPA/ORP Environmental Analysis of Carbon-14

EPA/ORP continued to evaluate the environmental impact of ^{14}C discharges from normal operations of uranium fuel cycle facilities. Upon completion of this study, a decision will be made on the need for an amendment to 40 CFR 190 (the uranium fuel cycle standard) for ^{14}C. The results of the Agency's evaluation are expected to be available in 1978.

Discharges of ^{14}C from the nuclear power industry are of particular concern partly because ^{14}C is a very long-lived radionuclide. Also, it becomes part of the carbon cycle, so it moves from the atmosphere and water to chemical structures of all life forms and back again. The anticipated maximum dose equivalent commitment to any single individual from ^{14}C discharges from uranium fuel cycle facilities is very small. The primary concern may be the cumulative risk to the world population over long periods of time.

Specifically, in 1977:

— EPA/ORP continued to study ^{14}C sources and control systems for light-water reactor facilities.

— EPA/ORP continued to evaluate the population dose commitment due to ^{14}C discharges to the atmosphere. The Agency assessment used a diffusion-type model of the global carbon cycle developed in 1977 by G.G. Killough at Oak Ridge National Laboratory (available as ORNL-5269 from the National Technical Information Service).

— Science Applications, Inc., completed a contract report to EPA in 1977 which assessed ^{14}C control technology and cost for the light-water reactor fuel cycle. The major conclusion is that caustic scrubbing is the best way to remove ^{14}C from waste gas streams and to leave it in a form compatible with permanent disposal conditions. (See Bray, Gary R.; Miller, Charles L.; Nguyen, Tien D., and John W. Rieke, "Assessment of Carbon-14 Control Technology and Costs for the LWR Fuel Cycle," Final Report for Contract 69-01-1954, EPA-520/4-77-013 (1977).

Appendix I

Since the adoption of Appendix I, which sets design criteria for nuclear reactors so that radioactive emissions are as low as practicable, the NRC staff has been developing radiological effluent Standard Technical Specifications to meet the requirements of the rule. These specifications provide monitoring, sampling, analytical and reporting requirements and are being prepared in the format of Appendix A (radiological safety), Standard Technical Specifications. Following approval by the Regulatory Requirements Review Committee, these specifications will be forwarded to all applicants for operating licenses for inclusion in the Final Safety Analysis Reports and to all licensees with operating licenses. Licensees will be requested to submit site-specific technical specifications as amendments to their operating licenses on a schedule to be determined by the NRC staff.

Fuel Cycle Standard

On December 28, 1976, Federal Regulation 40 CFR Part 190 was promulgated by the Environmental Protection Agency. This standard, entitled "Environmental Radiation Protection Standards for Nuclear Power Operations," requires that operations covered by the standard be conducted so that there is reasonable assurance that the annual dose equivalent to a member of the public exposed to planned discharges of radioactive materials and to radiation from the operation does not exceed a value of 25 millirems to the whole body. The standard also sets a thyroid and organ dose limit and provide curie-release limits for several specific radioisotopes. The standard is to be effective by December 1, 1979, except for two of the isotope release limits.

The NRC is responsible for implementing the EPA standard, which is somewhat less restrictive for a single reactor plant than the annual dose equivalents corresponding to the design objectives of Appendix I to 10 CFR Part 50. NRC has established a task force to work out the details of implementation, and it is considering such matters as the technical issues for implementation in licensing actions for all types of anticipated nuclear fuel cycle facilities, including sites having more than one reactor and sites having more than one type of facility. Need for amending existing NRC regulations is also being considered by the task force, as is the need to modify regulatory guides, standard review plans, technical specifications, and inspection procedures.

Study Review

Following up on its earlier reviews, EPA/ORP continued to question the ERDA sponsored *Reactor Safety Study's* treatment of health effects following a reactor accident. The methods used to estimate both early and late somatic effects were questioned: more documentation was seen as needed in the acute effects estimates, as they seem to differ from several published reports by responsible groups and investigators. EPA/ORP also objected to the Study's use of 30 year plateau absolute risk estimates from the BEIR report, because they are minimum estimates and may be out of date in several respects. These comments had a number of implications for the Study's calculations, and at the end of the year the agencies were still discussing their differences.

Environmental Impact Statements

While many agencies — often several dozen — comment on Environmental Impact Statements, EPA has primary responsibility. Therefore, and because of space limitations, only EPA/ORP responses are summarized here.

Mixed Oxide Fuel

Under a November 1975 policy statement of the Commission (40 FR 53056), the NRC began public hearings to help resolve the issue of whether and under what conditions uranium and plutonium might be recovered from spent light water nuclear reactor fuel and recycled in fresh mixed oxide fuel.

The hearings used as a basis the "Final Generic Environmental Statement on the Use of Recycled Plutonium in Mixed Oxide Fuel in Light-water Cooled Reactors—Health, Safety and Environment," publication number NUREG-0002, referred to as GESMO. Under the same November 1975 policy statement, the NRC also continued to process license applications for the construction, operation, and modification of facilities to reprocess spent fuel, fabricate mixed oxide fuel, and perform related functions. The U.S. Court of Appeals for the Second Circuit held, however, that the Commission could not issue such licenses for commercial-scale activities until it had completed the GESMO proceedings. Following the President's April 7 policy statement, NRC invited comments on its GESMO proceedings. In light of the comments and other events, the Commission decided at public meetings in December 1977:

(1) To terminate the GESMO proceeding.

Table 4.2

Standards for Normal Operations of the Uranium Fuel Cycle

A. Individual Dose Limits

1. Whole body	25 millirems/year
2. Thyroid	75 millirems/year
3. Other organs*	25 millirems/year

B. Limits for Long-Lived Radionuclides

1. Krypton-85	50,000 curies/gigawatt-year
2. Iodine-129	5 millicuries/gigawatt-year
3. Transuranics**	0.5 millicuries/gigawatt-year

C. Variances

At the discretion of the regulatory agency (licensor) for temporary and unusual operating circumstances to insure orderly delivery of electrical power.

D. Effective Dates

1. Two years, except
2. 1983 for krypton-85 and iodine-129.

*any human organ except the dermis, epidermis, or cornea.
**limited to alpha-emitters with half-lives greater than one year.

(2) To terminate the proceedings on pending or future plutonium recycle-related license applications, except for (a) proceedings on licenses for the fabrication or use of small quantities of mixed oxide fuel for experimental purposes, and (b) those portions of proceedings which involve only spent fuel storage, disposal of existing waste, or decontamination of existing plants.

(3) To re-examine the above matters after the completion of the ongoing alternative fuel cycle studies, now expected to take about two years.

(4) To publish the draft safeguards supplement to the GESMO document as a staff technical report.

Portsmouth Gaseous Diffusion Plant Expansion

Description: ERDA prepared a Draft Environmental Statement in November 1976 to assess the Portsmouth Gaseous Diffusion Plant Expansion. To accommodate U.S. needs for nuclear fuel as well as those of foreign customers, ERDA concluded that an additional plant would be required to ensure an adequate supply after 1985, and chose the Portsmouth site. While the Statement was being reviewed by EPA/ORP, the importance of the proposed action was enhanced as the new Administration put increasing emphasis on expanding enrichment capacity to achieve nonproliferation goals.

EPA/ORP Response and Status: EPA/ORP questioned whether possible alternatives had been given adequate consideration, and suggested that an expansion facility could be built at a later date if actually needed, using energy- and water-saving centrifuge technology rather than diffusion. Also, the Agency contended that analysis of the regional impact was insufficient.

President Carter then announced that the expansion facility would use centrifuge technology. Rather than issuing a new Draft Statement to deal with the greatly different system to be used, ERDA published a Final Statement the day before it became a part of DOE. It again stressed the diffusion process, referring to the "proposed facility" as a diffusion plant; the centrifuge technology which had been decided on was treated only as an alternative. Therefore, the discussion of its attributes and possible impacts was far less complete than it would have been had a full Statement been prepared, taking the Carter decision into account.

EPA/ORP submitted comments to ERDA and the Council on Environmental Quality to put the Agency on record as officially disapproving of the approach used in the Final Statement.

Floating Nuclear Power Plants

Description: An NRC staff Draft Environmental Statement was published in December 1975, covering the generic issues pertaining to the proposed siting of floating nuclear plants in the coastal regions of the Atlantic Ocean and the Gulf of Mexico (NUREG-75/113). The floating nuclear plant was conceived by the electric power industry some years ago as an alternative to land siting; its potential advantages include freedom from earthquake motions, an abundance of cooling water, and a relative isolation from populated areas.

EPA/ORP Response and Status: EPA/ORP rated the NRC generic Statement on siting and operation of FNPs inadequate, and presented its criticisms in testimony before the House Subcommittee on Energy and the Environment on July 27, 1976. Deficiencies cited were: (1) inadequate treatment of inshore siting options, (2) inadequate treatment of siting criteria, (3) lack of discussion of long term and cumulative impacts of a projected industry, and (4) lack of justification of eight plants for the first increment of production.

EPA/ORP also rated a subsequent Statement on the impacts of radioactive materials from accidents as inadequate. When the Final Environmental Statement on siting and operation of FNP was issued by NRC on October 1, 1976, EPA/ORP found it unresponsive to the comments and so informed the NRC and Council on Environmental Quality. The Statement on accidents has not been reissued, and resolution of EPA/ORP's concerns was underway at the end of the year.

Enforcement

Inspection Types

Planned NRC inspections are based on a defined program expressed in detailed inspection procedures, and are accomplished at prescribed intervals by NRC regional inspectors. Their principal objective is to provide reasonable assurance that licensed activities are conducted safely and in compliance with NRC requirements. This objective is met through selective examination of systems and functions, both administrative and physical, that have an impact on the safety and protection provided by each licensee.

Reactive NRC inspections respond to particular conditions or events which may affect the public's health and safety. Information on such conditions or events comes to NRC through notification by an applicant, licensee, contractor or supplier, or as a result of allegations by a member of the public. Each licensee is required to report any abnormal condition or event to the Commission, thus providing for continuous NRC monitoring of licensee operations. Compliance with these reporting requirements is examined during the planned on-site NRC inspections.

Action Taken

Several threshold levels of NRC action are provided to allow flexibility in the enforcement action response to reports of noncompliance:

— Written "notices of violation" are provided for a spectrum of matters where severity and punitive considerations are below the threshold of orders and civil penalties.

— Civil monetary penalties are provided as an incentive for licensees to assure compliance on a continuing basis. They are considered for licensees with chronic, deliberate, or repetitive items of noncompliance, generally where a "notice of violation" has not been effective. Civil penalties may also be imposed for certain first of a kind violations.

— Order to "cease and desist" operations, or for modification, suspension, or revocation of licenses are used to deal rapidly and conclusively with licensees who do not respond to civil penalties or to deal with violations that constitute a significant threat to public health and safety or to the common defense and security.

During FY 1977, a total of 15 civil monetary penalties were imposed upon licensees by NRC in order to enforce compliance with NRC rules and regulations.

Revised Inspection Program

During 1977, the Commission authorized the Office of Inspection and Enforcement to proceed with a revised inspection program that will place NRC resident inspectors full time onsite at power reactors and at major fuel cycle facilities. This program includes three major elements: (1) resident inspectors; (2) performance appraisal teams that will provide national (as opposed to regional) perspective on licensee performance and the effectiveness of the inspection program; and (3) expanded direct measurement of licensee activities and increased observation of licensee operations.

This revised program preserves the underlying philosophy that the licensee is responsible for all safety, safeguards and environmental measures necessary to protect the public. None of the additional observations, tests or measurements performed by NRC will replace any of those performed by the licensee but will serve to verify the licensee's ability to accurately conduct these tests.

Quality Assurance

Each NRC licensee is held responsible for assuring that his nuclear power plants are built and operated safely and in conformance with the NRC regulations. In addition, the NRC has several specific quality assurance (QA) responsibilities. First, it has a responsibility for developing the criteria and guides for judging the acceptability of nuclear power plant QA programs. Second, it has a responsibility for reviewing the QA programs of each licensee and his principal contractors to assure that sufficient management and program controls exist. Finally, NRC inspects selected activities to determine that the QA programs are being implemented effectively.

In order to assess independently the adequacy of NRC's regulatory practices in the area of quality assurance, the NRC contracted with Sandia Laboratories to do a comprehensive study on this topic. The results of this study were published in August 1977, generally endorsing current practices, while suggesting additional measures and potential improvements for NRC consideration. Some of these recommendations are being implemented, and others are being evaluated.

EPA Studies

Operational Analysis Program

EPA continued its program of operational analysis of nuclear facilities, publishing three new reports. Results of studies conducted under this program are used for a number of purposes:

— in reviewing environmental impact statements of nuclear power plants, particularly older ones,

— to improve predictive models,

— to provide additional data for use in EPA's program to develop environmental radiation protection criteria and standards for radioactive waste management,

— to assess actual performance against predictions in Environmental Impact Statements, and

— to review the adequacy of generally applicable radiation standards for the uranium fuel cycle.

In June 1977, EPA/ORP issued a report entitled "Summary of Radioactivity Released in Effluents from Nuclear Power Plants from 1972 through 1975" (EPA-520/3-77-006). The Summary is planned as an annual report, derived from a data file maintained on all significant radionuclides in LWR effluents (air, water and solid).

In addition to being used in the technology assessment of current waste management processes, the Summary will be useful in identifying sources with inadequate controls and in assessing compliance with Agency radiation standards, guides, and criteria. A follow up report covering 1973 to 1976 (EPA-520/3-77-012) is now available, although the earlier one is out of print.

A third major publication, in November 1977, was "An Analysis of Low-Level Solid Radioactive Waste from LWRs through 1975" (ORP/TAD 77-2). The study was undertaken to assess the volume and total radioactivity of the solid waste produced by an average reference LWR in a year. Both the volume and radioactivity were investigated, and an analysis was undertaken of the relative composition with respect to major radionuclides.

Gaseous Effluents from Reactors

In September 1977, EPA/ORP completed a draft report on its study of "Population Doses Resulting from Light-Water-Cooled Nuclear Power Plant Airborne Effluents." Differences were compared in the degree of environmental contamination that can be expected from the operation of boiling water reactors (BWR's) and pressurized water reactors (PWR's). The study also examined trends during 1970-74 in the release of mixed fission and activation products, noble gases, halogens and particulates, and tritium; BWR releases were higher than the PWR for all releases except tritium. The study is expected to be published in 1978.

EPA/ORP Radiation Studies at Nuclear Facilities

EPA/ORP continued its special field studies at selected typical nuclear facilities. In addition to helping develop measurement techniques and validate dose computational models, the studies are useful in characterizing effluents and determining whether technology to control nuclear wastes can meet design specifications. Some of the studies completed or in progress in 1977 were:

— *Quad Cities Nuclear Power Station:* A draft report was prepared during 1976 of a continuing joint EPA/NRC study of the iodine-131 to milk pathway at a boiling water reactor. Measurements included release rates and concentrations of iodine-131 in air, grass and milk. The draft report was reviewed and commented on during 1977, and the resulting changes were incorporated in the final document, which will be published in 1978.

— *G.E. Fuel Fabrication Plant:* EPA/ORP completed a study to characterize the stack effluents of a fuel fabrication facility, and to learn about types of radionuclides discharged and about significant environmental exposure pathways. As stated in a draft report, these data will be used to validate dose models for use in future estimates of individual and population doses. The final report will be issued in spring of 1978.

— *Browns Ferry Nuclear Power Plant:* Design and evaluation of an ambient radiation monitoring program was the major objective of a joint study begun by EPA/ORP, the Alabama Division of Radiological Health, the Tennessee Valley Authority and others. Only background data was gathered before the plant was shut down temporarily. The background data collected up to fall 1977 are being analyzed, and a report is in preparation. The EPA study resumed when the plant went back into service in fall 1977; a report on the data collected for the next year will be forthcoming in 1979.

Liver Cancer Risk

EPA/ORP developed a model to estimate the risk of liver cancer due to certain actinide radionuclides, based on data from patients treated with Thorotrast. Used medically, it has produced a pattern of biological effects similar to those expected from alpha-emitting radionuclides in the nuclear reactor fuel cycle. Because children's sensitivity to exposure is uncertain, and the model showed it could affect estimates more dramatically than other factors, EPA/ORP concluded that the Thorotrast data should be analyzed to provide age-specific information on cancer risks. Of particular importance is the need to make all Thorotrast studies consistent so data may be compared. (See Nelson, N.S., Ellett, W.H., Cook, J.R., and F.A. Hodge, "Estimated Risk of Liver Cancer Due to Alpha Emitters and Beta-Alpha Emitting Parent-Daughter Chains; An Application of Thorotrast Data," to be published, Environmental Research (1978).)

NRC Studies and Reviews

NRC Advisory Committee

The Advisory Committee on Reactor Safeguards is a panel of independent advisors established by law to review and report to the NRC on safety studies and license applications for nuclear power reactors and other major nuclear facilities, such as spent fuel processing plants. The Committee also provides advice to the Commission on a wide range of safety-related matters, such as the adequacy of proposed reactor safety standards, reactor safety research, specific technical issues of a topical nature, and the safety of operating reactors.

In its review of proposed facilities during the report period, the Committee gave special emphasis to the following safety-related matters:

- Analysis of systems interactions in nuclear power plants, including the physical configuration of safety systems and interrelated functions and actions.

- Innovative safety features, such as the upper head injection system and ice condenser containment system.

- Methodology applied to the seismic evaluation of nuclear power plant sites and structures.

- Physical protection of nuclear facilities and safeguards for special nuclear material.

- Reliability of safety-related systems, such as the DC power supply in nuclear power plants.

The Committee has also given considerable attention to the following subjects at the specific request of the NRC:

- Packages for air shipment of plutonium and transporation of other radioactive materials.

- Long-term waste management for high-level and low-level wastes.

- Specific reactor safety issues which have been raised by members of the NRC technical staff.

The Committee's advice was also requested by the NRC on the environmental survey of the waste management portions of the light-water-reactor fuel cycle, and a report was provided to the Commission in early 1977. This action represented the first time the Committee had become involved in the review of environmental matters, though future efforts in this area are expected.

Environmental Review

The NRC environmental review process under NEPA provides for the establishment of operating limitations and monitoring requirements for each nuclear plant. Their purpose is to assure that the plant meets design specifications and to verify anticipated environmental impacts. Control measures are incorporated into operating licenses by means of Environmental Technical Specifications (ETS), which specify appropriate limiting conditions for operation and provide detailed procedural requirements for conducting the monitoring programs. Significant progress has been made in our understanding of the environmental issues involving power plants since the program was initiated in 1971. A frequent practice in early monitoring programs was to place general requirements on licensees, which resulted in the generation of large amounts of data, much of which proved to be extraneous. Recently ETS have become more streamlined, focusing directly on those issues of environmental concern that are identified in environmental impact statements.

Another improvement in the licensing process is a recently initiated program to establish conformity in the ETS process. This is being accomplished by selecting representative power plants at the operating license stage and developing ETS for them in a format readily applicable to other plants. Details will vary from plant to plant, but the underlying principles and objectives will be consistent for all.

Environmental Dispersion

A unified transport model was developed by NRC for use in coordinated thermal, chemical, radioisotope and plume entrainment analyses to provide a reliable method for predicting dispersion of power plant discharges to lakes, rivers, estuaries and other waters. Levels of radioiodine, carbon and tritium in the vicinity of the Quad Cities nuclear station in Illinois were measured as part of a study to identify the species of radioiodine in reactor effluents and to confirm environmental assessments and predictions made in connection with power plant licensing.

Ecological Impact

A series of studies has been undertaken by NRC to assess, confirm or improve methods for predicting the potential impacts of the nuclear industry on important species, ecological systems and physical environments. Studies in progress to develop and test methodologies for predicting the impact on populations of important fish include recent modeling and measurement studies to assess the impact of nuclear power stations at Indian Point, N.Y. on the population dynamics of striped bass in the Hudson River. Other studies have modeled and measured the dilution, distribution and effects of chemical antifouling agents in reactor cooling water discharges.

Socioeconomic and Regional Studies

NRC studies of secondary socioeconomic impacts associated with construction and operation of nuclear power stations at Plymouth, Mass., and Waterford, Conn., were undertaken in connection with environmental impact statements associated with power plant licensing. Work also continued during the 1977 on the study of future electricity demand in individual States. At the end of the period, the projected demands in 15 states had been examined, and the results were being used in analyzing the need for power in the cases of the Marble Hill and Erie nuclear stations. The Energy Facilities Siting Council of the Commonwealth of Massachusetts and NRC initiated a joint project to develop a methodology for assessing energy facility siting on a regional basis.

DOE Studies

Environmental Studies

DOE continued programs to investigate the potential of nuclear fuel cycles for contaminating the environment with effluents containing transuranic and fission product radionuclides. Little information is available on the behavior some deposited effluents exhibit under agricultural conditions and in natural ecosystems, and there are no reliable estimates of the persistence of transuranium elements in our environment. Another gap in our understanding is the composition and behavior of energy and weapons related pollutants in the stratosphere, and how they are affected by natural processes.

DOE's research program encompasses studies to address these issues in many different ways. Transuranic element mobility is being assessed from the results of laboratory experiments and field studies where detectable levels of elements such as plutonium are known to exist: the Great Lakes, Ohio River/Mississippi River Basins, Atlantic Coastal Plain, Western desert regions, U.S. coastal regions, the Irish Sea and the North Pacific. In 1977, the role of microbiological activity was studied in soils and sediment, and showed that small amounts of plutonium and other actinides are incorporated as organic complexes. Such organically incorporated substances pose a much greater hazard to people by ingestion.

Transuranium elements are also being evaluated in terms of their persistence as a potential hazard, and their transport from the environment to the human population. Among the specific studies conducted in 1977 are:

— For the Miami/Ohio River, Hudson River and Savannah River, results indicated that almost all of the transport of transuranium elements was associated with sediment movement.

— A program on baseline concentrations and the fate of transuranic elements was initiated in the Clinch River to determine what has been released from Oak Ridge and retained in sediments nearby.

— Additional information was collected on the depositions of transuranium elements during harvesting of agricultural food crops.

— Losses of radioactivity from bottom sediments in North Pacific Gyre were estimated as part of a study to identify acceptable future waste disposal sites of high level wastes.

— Thorium and uranium studies were begun in the laboratory and the field to determine their transport, fate, and effects in the environment.

— To address the problem of pollutants in the stratosphere, a high altitude sampling program is operated in the Northern Hemisphere to document the concentrations of selected aerosols and gases as a function of latitude, altitude and season. In 1977, more samples were collected, and NASA contractors developed a new sampler to provide greater detail at less expense.

Environmental Control Systems Analysis

DOE conducted an analysis of systems and technology for controlling radiological and chemical effluents from alternative light water reactor fuel cycles. The adequacy of these systems in terms of present and proposed effluent limits will be evaluated. Fuel cycle options considered were limited to those related to nonproliferation, but eventually other possibilities such as the High Temperature Gas Reactor fuel cycle will also be assessed. In a related area, DOE is conducting a program of analysis and testing to affirm the adequacy of fuel and waste containment casks used throughout the fuel cycle. Technical information is being collected to:

— maintain the existing transportation accident data bank,

— collect and publish statistics and data on DOE's own transportation operations program, and

— develop films, booklets, and exhibits on the environmental and safety aspects of the transportation of fuels and wastes.

Physical and Technological Studies

DOE conducts research on mechanisms of radiation interaction with living cells and formulates descriptive models predicting biological effects. Improved dose-effect models were used in 1977 for health protection and radiation therapy application. Basic reseach was continued on new materials, detector concepts and electronics improvements, with emphasis on development and evaluation of field instruments. Prototype *in-situ* monitors were completed for detecting low levels of uranium and transuranium isotopes in soils.

b. Wastes

Guidance

EPA Criteria and Standard

In September 1976, the President directed EPA to prepare specific numerical standards for environmental protection from high level radioactive wastes. They will apply to both defense and commercial wastes in any form. While the President's decision against reprocessing changes predictions about how much of what kind of waste there will be, a standard is needed in any case to apply to existing wastes. EPA decided to begin developing the standard simultaneously with formulating general criteria, because of the urgency of the issue.

The criteria, to be completed in 1978, will express the basic philosophy that should pervade all agencies' waste standards, including EPA's, and will outline the kinds of considerations which should be taken into account in formulating them. The criteria will apply to all types of radioactive wastes.

EPA/ORP launched the criteria development process with two open public workshops held in Albuquerque, N.M. and Reston, Va. (near Washington, D.C.). The purpose was to listen to the public's views on policy and technical issues pertinent to developing criteria—what factors should be considered and how they should be weighed. Participants divided into smaller working groups to address more specific topics, and then wrote reports on the issues they saw as important. Among the questions discussed were:

— whether wastes should be retrievable in any way

— whether and in what way accidents and unplanned events should be taken into account

— what information the public should have to make decisions about radioactive wastes

— how risks from different wastes should be taken into account in developing criteria applicable to all wastes

— what our responsibilities are to future generations

— for how long isolation should be assured for surface burial

— what controls should be imposed to minimize the radiological impact to the populations.

A surprising degree of consensus emerged from the groups, which varied greatly in background and viewpoint. Some basic guiding principles emerged, such as the idea that future generations should not be subjected to greater risks than present ones and that retrievability should be considered only when safety will not be compromised. As a next step, the EPA staff developed initial formulations of proposed criteria, and planned to hold a 1978 Public Forum to enable the public to provide the agency with detailed, written comments from working groups.

Three ongoing contracts were initiated in 1977 as part of developing the high level waste standard the President has directed EPA to issue during 1978. The first contract will produce a technical document discussing (a) sources and total quantities of waste existing and expected, (b) engineering barriers, such as the glass matrices in which wastes may be solidified, (c) transportation pathways from the wastes' resting place to biosphere and people, and (d) the risk of various kinds of accidents and their possible consequences. In compliance with National Environmental Policy Act, a second contractor is assisting in the preparation of a draft Environmental Impact Statement examining alternative means of disposal, such as seabed and outer space, the cost/benefit aspect of risk reduction, the long term commitment of resources, and related issues. Third, the National Academy of Sciences formed a panel at EPA's request to investigate whether reasonable means exist to provide assurance that the standard could be implemented by the Department of Energy and the Nuclear Regulatory Commission. It will look into matters like how compliance with the standard can be demonstrated.

Spent Fuel Storage

The problem of dealing with the growing inventory of spent reactor fuel,which is being addressed by the NRC, involved standards support in both regulations and guides. There is a need both for increased storage capacity at existing reactor storage pools and for storage facilities at sites other than reactors. A revision to Guide 1.13, on the design of storage facilities at reactors, is under development. Work continues also on a proposed rule for licensing independent spent fuel storage installations and on guides for license application, facility siting, design requirements, and plant proposed rule for licensing independent spent fuel storage installations and on guides for license application, facility siting, design requirements, and plant protection for such facilities.

Waste Classification

One of NRC's programs is aimed at classifying wastes according to the degree of confinement necessary to ensure their containment until they decay to some acceptable low-risk level. Criteria will be developed to specify what wastes: (1) require isolation in a Federal repository—probably high-level reprocessing wastes, spent fuel, and transuranic contaminated wastes: (2) require confinement in a commercially operated waste disposal facility (shallow land burial)—probably operating reactor wastes other than fuel, structural materials from decontaminated reactors and radioactive medical wastes; or (3) can be dispersed to the environment. The criteria will, among other things,specify the highest permissible transuranic content of wastes which can be disposed of by shallow land burial.

High Level Waste

NRC's proposed regulations regarding HLW repositories are scheduled to be published for public comment in the fall of 1978. These regulations will address:

(1) Performance criteria for HLW solids, i.e., what form wastes must take in a HLW repository.

(2) Site suitability criteria, i.e., what constitutes an acceptable site for a repository.

(3) Repository design criteria, i.e., what constraints must be placed on construction and operations of a repository.

(4) Licensing procedures, i.e., what mechanisms will be used to review proposed facilities to determine if they meet the criteria.

The waste form criteria, site suitability criteria and respository design criteria will specify how the wastes, the site and the respository *should* perform. The NRC staff is also developing methods for predicting how a proposed HLW repository *will* act and whether the predicted actions will meet minimum performance requirements.

NRC recognizes that the States have a significant interest in, and can make a substantial contribution to, the development of HLW regulations, particularly with respect to site suitability criteria. Accordingly, three regional workshops were held in September 1977 to facilitate State review of preliminary drafts of proposed site suitability criteria. Information developed at the workshops will be considered in preparing the draft environmental impact statement in support of the criteria. Proposed site suitability criteria and the draft impact statement will be published for public comment early in 1978.

Performance Criteria for Solidified Reprocessing Wastes

The NRC staff is using a system-analysis model to evaluate the various situations which could lead to release of radioactive materials during handling, storage, transportation, and disposal of high-level solid waste from reprocessing. A similar systems analysis approach will be used to develop performace criteria for spent fuel disposal in deep geological structures.

The three basic mechanisms that control the release of radioactive materials are *volatilization, dispersion of particulates and leaching by water*. The performance criteria will require control of each of these mechanisms and will be based on an analysis of the possible pathways to waste release, the state of technology for controlling each mechanism, and a balancing of the cost of control against the benefits achieved by reducing the risks to individuals and populations.

The results obtained to date indicate that the hazards present before the waste is placed underground may be more important in determining the proper solid waste form than those encountered after the waste is placed underground.

Decontamination and Decommissioning

An important aspect of the waste management program is the decontamination and decommissioning of nuclear installations once they have completed their useful lives. Technical studies for NRC are continuing at the Batelle-Pacific Northwest Laboratory (PLN) to develop decontamination and decommissioning criteria for light water reactors and fuel cycle facilities. These will be used in developing appropriate regulations and guides. A PNL report on the decommissioning of fuel reprocessing plants (NUREG-0278) was published in October 1977.

Low Level Wastes

As part of the NRC's continuing reexamination of the technical and regulatory bases for the management of radioactive wastes, and in response to Congressional concerns, an "NRC Task Force Report on Review of the Federal/State Program for Regulation of Commercial Low-Level Radioactive Waste Burial Grounds" (NUREG-0217) was published in March 1977.

In developing its recommendations, the task force was concerned with the objectives of the low-level waste management program which include establishing a regulatory structure, assuring adequate waste disposal capacity without a proliferation of sites, assuring long-term care without placing a disproportionate burden on a few States, providing for appropriate Federal and State participation and examining alternative disposal methods.

Based in part on this report and on 33 public comments received on it, the Commission announced a program in December 1977 which included the following major elements:

- *The NRC staff will accelerate development of a comprehensive set of standards and criteria* for disposal of low level waste and will examine alternatives to shallow land burial, the only method used at present. This work will be done in cooperation with State governments and with other Federal agencies, including the Department of Energy, the U.S. Geological Survey, and the Environmental Protection Agency.
- *Any new land disposal sites will have to be fully justified on the basis of need.* Additional capacity may be needed because of regional needs, equipment limitations, costs and other factors. NRC will be working closely with the States to which it has transferred licensing authority to assure that applications are treated in a similar manner whether under NRC or State licensing jurisdiction.

Education

NRC Workshop

In January 1977, a workshop on Reactor Radwaste Management, organized and conducted by the Oak Ridge National Laboratory (ORNL) and NRC, was held in New Orleans, La. The workshop was intended to provide information needed to update four generic reports (under preparation by ORNL for the NRC) and to provide an opportunity for those in the field of radioactive waste management to assess process equipment performance under actual operating conditions. The workshop was attended by 190 persons, including representatives for various Federal and State agencies, utilities, nuclear steam supply vendors, architect-engineers, and radwaste equipment vendors.

NRC also sponsored, along with EPA, DOE, USGS and ASME, a Symposium on Management of Low-Level Radioactive Waste in Atlanta, Georgia on May 23-27, 1977. Problems and issues were discussed by officials at different levels of government as well as the private sector.

Study Review

Impacts of Reprocessing and Waste

EPA/ORP reviewed NRC's responses to the comments EPA submitted on its "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle" (NUREG-0116). Supplement II to the initial survey, in addition to dealing with comments, provided additional information on the environmental impacts associated with the management of nuclear fuels and wastes. The Supplement was reviewed in terms of the adequacy of its reaction to EPA's comments on the original document. In general, the Agency concluded that its concerns were not addressed. Among the most important of these were the use of certain estimates and models which were developed for the Reactor Safety Study, the presentation of environmental impacts from radiological releases, problems associated with disposal of low-level wastes, failure to incorporate an assessment of impacts from mining and milling wastes, and the frequent reference to information from the Environmental Impact Statement for the uncompleted GESMO hearings.

At the end of the year EPA/ORP was preparing to testify before the NRC Hearing

Board which has been convened by the Commission to assess the adequacy of the staff's reports.

Environmental Impact Statements

Waste Management Operations at Savannah River Plant

Description: ERDA issued a Draft Environmental Statement on "Waste Management Operations at Savannah River Plant, Aiken, South Carolina" (ERDA-1537) in October 1976. It presented a history of earlier practices as well as projecting and analyzing the actual and potential environmental effects of future operations.

EPA/ORP Response and Status: EPA/ORP expressed grave concerns about the possible impact of bedrock storage of wastes, which would involve injecting them below the Tuscaloosa aquifer, the principal water supply for most of southeastern South Carolina and Georgia. The governor of Georgia joined EPA in opposing the planned bedrock storage, and it was abandoned at least for the time being. EPA/ORP also suggested that, in the future, the impacts of decommissioning nuclear facilities and radioactive waste disposal sites should be assessed prior to approval for operation, simultaneous with approval of plans for the funding needed for decommissioning and subsequent caretaking. The Final Environmental Statement was issued in September 1977, including a response to EPA's comments. The Agency reviewed the responses and decided not to make further formal comment.

Oak Ridge Intermediate Wastes

Description: ERDA issued a Draft Environmental Statement for the Management of Intermediate Level Radioactive Waste at the Oak Ridge National Laboratory in Tennessee (ERDA-1533-D) in January 1977, and a final version in September 1977. It was prepared to support an administrative action to select a preferred technique for the management of intermediate level radioactive waste, and the construction and operation of a facility to implement the technique. Three alternative techniques were assessed in terms of their environmental impacts: hydrofracture, shale-cement fixation, and glass fixation.

EPA/ORP Response and Status: EPA opposes emplacement of materials by subsurface injection without strict controls and a clear demonstration that it will not, among other things, damage the environment. In addition, the Agency concluded that more hydrogeological information was needed, all reasonably achievable precautions should be taken, safe drinking water limits should be considered, and the intent of the EPA proposed Regulations for State Underground Injection Control Programs (41 F.R. 36730) should not be violated. It was also suggested that the forthcoming criteria for radioactive waste management should be considered in the ERDA plan. ERDA responded to these points in its Final Statement, which EPA reviewed and concluded that it would make no further formal comments to ERDA.

Brookhaven National Laboratory

Description: The Final Environmental Statement ERDA issued in July 1977 covered its Brookhaven National Laboratory site operations at Upton, N.Y. The Statement covered environmental and monitoring data, past laboratory operations and environmental effects with respect to off-site consequences.

EPA/ORP Response and Status: EPA/ORP found that the Final Statement was responsive to the concerns it expressed with regard to the Draft Statement.

Waste Management Operations at Idaho National Laboratory

Description: The Final Environmental Statement ERDA issued in September 1977 discussed the current waste management operations at the Idaho National Engineering Laboratory and the impacts associated with continuing the programs of converting the stored high-level wastes to solids using calcination. Alternatives included additional treatment, transfer of wastes off-site and continued operation.

EPA/ORP Response and Status: The Final Environmental Statement was responsive to the concerns EPA/ORP voiced regarding the Draft, so no further comments were submitted to ERDA.

Studies

EPA/ORP Research on Burial Sites

EPA/ORP is working to determine the impact of ground disposal of radioactive wastes on a practical, field-oriented basis by conducting studies at operating commercial burial facilities. Thus far, studies have been conducted, in close cooperation with the States of New York and Kentucky and the U.S. Geological Survey, at the Maxey Flats, Kentucky and West Valley, New York burial sites. At Maxey Flats, preliminary environmental pathways and evaporator effluent studies have already been completed, and preliminary hydrogeological and radiological studies are in process; at West Valley, EPA/ORP has finished a preliminary radioactivity migration study and is continuing a four-year detailed environmental pathways study scheduled for completion in 1979. Also, as a result of the Clean Air Act Amendments of 1977, EPA is now planning a program to assess the nature and magnitude of radioactive air emissions from low level wastes in shallow land burial sites.

In addition, EPA/ORP is conducting or sponsoring several smaller studies aimed at specific segments of the land burial problem, such as determining what wastes are buried in the burial grounds; factors which affect the retention of radionuclides by soil; potential improvements in site engineering, operations and water management; and development of criteria for selection of a burial site.

Specifics on sample programs follow:

— *Characterization of reactor-generated low level radwastes:* EPA/ORP funded a study investigating the radionuclide makeup of light water reactor radioactive wastes presently being consigned to shallow land burial. Chemical analyses were made of spent ion exchange resins, evaporator concentrates, and filter sludges for specific radionuclides. Waste samples from four reactors were analyzed to determine a number of radionuclide concentrations. A report was issued, "Characterization of Selected Low-Level Radioactive Waste Generated by Four Commercial Light-Water Reactors" (Technical Note ORP/TAD-77-3, December 77).

— *Environmental survey of packaging for solidified low level radwastes:* EPA/ORP is funding a study to analyze packaging methods and techniques for solidified low level radwaste, simulating environmental conditions present in shallow land burial and deep ocean disposal. Considerations will include physical, chemical and radioactive properties which affect the durability of the packages, and practices currently followed both in the U.S. and in other countries. A report will be issued in 1978.

— *Inventory and projections of low level radwastes for burial at commercial facilities:* EPA/ORP prepared a report of the inventory (through 1976) of low level radioactive wastes buried at the six commercial facilities. These data update a 1974 report and were compiled through arrangements with various State regulatory agencies. A projection or prediction of future waste volumes for comparison with existing capacity was included. (The report was issued in *Nuclear Safety*, Volume 19, No. 1, January-February 1978.)

Maxey Flats Radiological Measurement

In January 1977, EPA/ORP's Eastern Environmental Radiation Facility (EERF) published "Radiological Measurements at the Maxey Flats Radioactive Waste Burial Site—1974 to

1975" (EPA-520/5-76/020). It discusses measurements made in support of EPA's program to obtain data on the principles and processes of land burial, and on the actual impact on the environment of presently operating commercial burial facilities. The measurements were obtained in cooperation with the Kentucky Department for Human Resources, and furnished technical support requested by the State.

The information obtained indicates that radioactivity has been detected in the unrestricted environment, outside the burial trenches and off-site. However, the quantities are sufficiently low that they do not appear to be a significant hazard to the environment or to public health in the Maxey Flats area at the present time. On the other hand, because Maxey Flats has been operational for only a relatively short time, EPA is not in a position to assess conclusively whether or not any future movement of radioactivity will be greater or less than the small amount of leakage observed to date. Thus EPA believes additional efforts are needed to develop and implement acceptable environmental protection assurances for permanent disposal options.

EPA also believes that shallow land burial will probably remain an important management method for at least a few more years, and it is important to improve present practices as much as possible.

As part of EPA/ORP's implementation of the Clean Air Act Amendments of 1977, general protocols were drafted to evaluate radioactive gaseous emissions and resuspension from four commercial shallow land burial sites. The studies would be conducted by EPA/ORP's two field laboratories, Eastern Environmental Radiation Facility at Montgomery, Alabama, and Las Vegas Facility at Las Vegas, Nevada. The resulting data would be used to evaluate which radioactive air pollutants should be controlled.

Although no new field studies were undertaken in 1977, EPA/ORP began an in-house study evaluating a number of models for risk assessment of the shallow land burial sites. By examining each model's features, staff will determine if (a) any single existing model can be used to evaluate specific sites, (b) if combining several of the models will be adequate, or (c) if new attributes or models are required.

West Valley

Following the announcement by Nuclear Fuel Services, Inc. that it was withdrawing from the fuel reprocessing business, the NRC staff began a special study on the adequacy of high-level waste storage at the company's West Valley, N.Y., site. While ultimate responsibility for the site remains an open question, the staff has continued to follow conditions at the site. Specifically, in June the staff issued an interim safety evaluation on the current reduced operations at West Valley. The staff concluded that these operations presented no undue risk to the health and safety of the public or of employees.

The staff has continued to conduct confirmatory studies of the effects of natural phenomena on the dormant plant. It also has requested support from the DOE in developing a scheme for the safe, practical disposal of the high-level waste stored there.

NRC Radioactive Waste Disposal Classification Study

EPA/ORP was represented on a Technical Advisory Panel to the NRC Radioactive Waste Disposal Classification Study. As part of its activities, EPA reviewed several reports by a contractor: "Determination of Radioactive Waste Classification System," and "Compilation of the Radioactive Waste Disposal Classification System Data Base." EPA suggested that the Study should take into account its forthcoming criteria for radioactive wastes, and should calculate environmental dose commitments from the radioactive waste management options considered.

Panel of Earth Scientists

To support its efforts to develop environmental standards for high level radioactive waste management, EPA initiated a contract in 1977 to evaluate the adequacy of the state of knowledge in the earth sciences for estimating the environmental impacts from deep geological disposal of high level radioactive waste. The final report, which will be available early in 1978, will be an important part of the technical basis for the standards. EPA is using state of the art techniques to estimate possible impacts from waste repositories, including those located in deep geological formations.

However, the Agency recognizes that there may be significant uncertainties and controversy regarding knowledge of rock properties, hydrogeology, and other factors, especially as they relate to the ability to provide long term containment of radioactive wastes. Therefore, EPA directed its contractor to convene an independent Panel of Earth Scientists to advise the Agency of the range of uncertainty of estimates of environmental impacts. The panel consists of recognized experts in basic earth sciences, who have had little or no prior involvement with radioactive waste programs. Its evaluation is to be performed independently of EPA, its contractors, or other government agencies.

c. Spent Fuel

Environmnental Impact Statements

In a *Federal Register* notice on September 16, 1975, NRC directed its staff to prepare a "Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel." During fiscal year 1977, a draft environmental statement was completed for internal review and was to be issued for public comment in March 1978. In the draft statement, the staff estimates that some 95,000 metric tons of spent fuel may be discharged from light water reactors through the year 2000. In order to arrive at an estimate of the maximum environmental effect, it is assumed that none of this spent fuel will have been reprocessed or permanently stored by the year 2000. The statement examines the ability of traditionally designed reactor pools to accommodate this discharge and the impacts of providing and not providing adequate storage.

The staff's analysis in the draft statements shows that the spent fuel which will be generated through the year 2000 can be accommodated by modification of present storage arrangements at each nuclear reactor and by providing storage space at locations away from the reactors. The staff found that this solution is both environmentally and economically less costly than its alternatives.

The draft statement reaches two conclusions based on these findings:

1. No modification of 10 CFR 51.20(e)—the summary of environmental considerations for the uranium fuel cycle—appears necessary.

2. The NRC should publish a rule and associated regulatory guides to regulate the anticipated growth in away-from-reactor storage.

In keeping with the second conclusion, a proposed rule for away-from-reactor storage, 10 CFR Part 72, and a revised Regulatory Guide 3.24, "Guidance on the License Application. Siting Design and Plant Protection for an Independent Spent Fuel Storage Installation," will be issued in 1978 for public comment.

d. Transportation

Administration

In June 1977, the NRC issued a topical report—"Regulatory and Other Responsibilities as Related to Transportation Accidents" (NUREG-0179)—to clarify the regulatory and other responsibilities of the different parties involved in dealing with those few transportation accidents involving radioactive materials that may be expected to occur each year. Any further changes in responsibilities will be covered in appropriate procedural documents, including the Memorandum of Understanding between NRC and DOT, or by rulemaking.

Studies

NRC and the Department of Transportation have begun a study of the adequacy of existing requirements for the shipment of material containing a low level of radioactivity. The study was undertaken following a truck accident in September 1977 in which a shipment of uranium concentrate (yellow cake) was spilled onto a highway near Springfield, Colo. Key subjects in the study will include an analysis of current packaging requirements to seek ways to make packaging more accident resistant; emergency planning; routing of shipments; and State and Federal licensing requirements.

With the technical assistance of Sandia Laboratories, an NRC environmental impact statement was prepared to assess the impacts associated with the transportation of radioactive materials, including relative costs and benefits of alternative modes of transportation. Information derived from research into the accident-resistant properties of packages used for shipping plutonium and from the NRC's 1975 Radioactive Material Shipments Survey were used in preparing the statement. The draft statement (NUREG-0034) was made available for public comment in March 1976. About 30 letters of comment were received. The final statement (NUREG-0170) was released to the public in December 1977.

The study indicates that transportation of radioactive materials is being conducted under the present regulatory system in an adequately safe manner. For example, radioactive shipments may be expected to add only one latent cancer fatality per year from routine shipments and one case per 200 years from accidents, assuming 1975 accident and shipping rates. By 1985, it is expected that these estimates might increase three-fold as a result of an increased volume of shipments. These rates compare to a nationwide total of 300,000 cancer deaths per year from all causes.

The NRC continued a study, initiated in May 1976, which will lead to a generic environmental impact statement on transportation of radioactive materials in urban areas. Information produced by the study, being performed with the assistance of Sandia Laboratories, will be used to assess current regulations with respect to the special problems posed by urban environments. An interim report, describing progress to date in the modeling and data collection efforts on this study, was released to the public in April 1977.

Report on Transportation Accidents at Sea

EPA/ORP reviewed a DOE sponsored report on "Consequences of Postulated Losses of LWR Spent Fuel and Plutonium Shipping Packages at Sea" (PNL-2093, UC-71, October 1977). Praising the report as the first effort to deal with transoceanic shipping of spent fuel and plutonium, EPA questioned the dose equivalent calculations and several aspects of packaging. For example, the report assumed that a ship would be carrying only one plutonium package or cask, and EPA/ORP believed that the possibility of multiple package loss should be considered.

Enforcement

Abnormal Occurrences

Under Section 208 of the Energy Reorganization Act of 1974, NRC is required to ". . . submit to the Congress each quarter a report listing for that period any abnormal occurrences at or associated with any facility which is licensed or otherwise regulated pursuant to the Atomic Energy Act of 1954, as amended, or pursuant to this Act. For the purposes of this section, an abnormal occurrence is an unscheduled incident or event which the Commission determines is significant from the standpoint of public health or safety. . . ."

NRC has developed two major interim criteria, according to which abnormal occurrences are: (1) events involving an actual loss of the protection provided for the health or safety of the public; and (2) events involving major reduction in the degree of protection provided.

During fiscal year 1977, a total of 19 events fell into this category. Nine of them involved accidents with radiographers using radioactive materials for medical, educational and industrial purposes. Failure to shield sources brought about several of the incidents. At fuel cycle facilities, reported occurrences resulted from a loss of electrical power, defective steam generator tubes, nuclear material discrepancies, feedwater nozzle cracking, and other causes.

e. Emergency Response Planning

EPA, along with other Federal agencies, is responsible for providing assistance and training to State and local governments in the development of their radiological emergency response plans to protect the public from the consequences of possible radiation accidents. As defined in the *Federal Register* of December 24, 1975, EPA's responsibilities are the development of guidance for the States in the areas of Protective Action Guides, protective action, and instrumentation for radiological emergencies.

Guidance to States

EPA provides, for the guidance of State and local governments, a "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents" (EPA 520/1-75-001). It contains practical guidance on criteria to use in planning for radiological emergencies that could present a hazard to the public, and guidance for planning and implementing protective actions. The Manual is only partially complete, and finished portions have been issued for use. One appendix, which is under development, will provide technical bases used for calculating projected doses from airborne releases. It was drafted and circulated for review by States, industry, and Federal agencies during 1976. Comments have been incorporated as appropriate, and it will be issued in final form in 1978, along with another appendix titled "Planner's Evaluation Guide." During 1977 a Manual Chapter on planning for response to transportation accidents involving radioactive materials was drafted by EPA/ORP's Las Vegas Facility, and will be incorporated into the Manual in 1978.

The responsibility for direct assistance to States for development and testing of their plans was transferred to EPA's Regional Offices. EPA's representatives participated with other agencies in reviewing State plans to permit Federal concurrence, and helped review exercises of the plans. In 1977, NRC concurred in four plans for the States of New Jersey, Connecticut, Washington and South Carolina. In another interagency activity, the final report will be published in 1978 of a task force NRC and EPA formed to identify the type of accidents States should plan to respond to.

Protective Action Guides

EPA/ORP continues to develop separate Protective Action Guides (PAG's) for three accident phases:

1. The plume exposure phase, when quick decisions and actions would be required to protect the public from whole-body external and inhalation exposure. These guides, originally issued as EPA/ORP guidance only, establish a dose range for both the whole-body and the thyroid. Technical support documents with the rationale for the PAGs are being prepared for submission to the President and promulgation as Federal Guidance. If approved, the Guidance will be mandatory for all Federal agencies in the development and implementation of their emergency plans.

2. Ingestion phase, when principal concerns would be for ingestion of contaminated food and water. EPA/ORP reviewed and commented on a draft DHEW/FDA report to be used as the basis for new ingestion PAG's slated for publication in 1979.

3. Long-term or recovery phase, when low-level direct radiation and contaminated food would be the critical exposure pathways. PAG's for this phase will be based on cost/risk analyses resulting from studies currently being conducted by a contract to be finished in 1978. They cover the cost-effectiveness of control

methodologies (protective actions) for exposure from contaminated property and equipment.

Protective Actions

Protective actions to be considered for plume exposure pathways are evacuation, shelter, and iodine blockage. Contract studies comparing the relative effectiveness of evacuation and shelter have been completed and reviewed by Federal agencies, resulting in two technical reports to be published in 1978. Guidance based on the two reports was drafted in 1977, and will be circulated for review by Federal and State agencies. It is scheduled for publication as an Appendix to the EPA Manual in 1978.

The NCRP completed a study and published a report (NCRP #55, August 1, 1977) on the use of prophylactic iodine to protect the thyroid from radioactive iodine. The Food and Drug Administration is currently evaluating the feasibility of making the iodine available in the form of tablets, which might be available during an emergency on a nonprescription basis. If those actions are approved, EPA will develop application recommendations as a protective action.

Instrumentation for Radiological Emergencies

The Federal Interagency Task Force on Off-site Emergency Instrumentation Systems, formed in 1974, continued to develop guidance to State and local officials on off-site radiation detection systems and associated instrumentation. The Task Force is evaluating a portable, field operated monitor which can measure elemental and organic forms of airborne radioiodine in the presence of noble gases; initial tests appear favorable. Also in 1977, the Task Force completed a revised draft report, "Guidance on Off-site Emergency Radiation Measurement Systems, Phase I—Airborne Releases."

Training Programs

EPA participates in an Interagency Task Force on training and exercises which has the overall responsibility for identifying and guiding the development of training programs for planning and responding to radiation accidents by State and local officials. Two courses dealing with response to radiation accidents were provided in 1977, and an existing course on planning was updated. EPA is responsible for development and coordination of presentations for one of the training programs, designed for State radiological emergency response coordinators and their staffs. Course material was developed for the plume exposure phase of the accident. By the end of 1977, this training was presented to selected officials in 36 States with major nuclear facilities in operation or nearing completion. The second response course, "First at the Scene," was developed by NRC for State and local officials and conducted by a contractor seven times in 1977.

EPA's Region IV conducted a workshop of State, Federal, and industry representatives on testing emergency response plans, resulting in a draft report outlining the steps necessary to plan and conduct a test.

Interagency Activities

A major action to enhance Federal cooperation was taken in 1977, when interagency agreements were made with both DOE and NRC to provide for prompt notification of EPA when there is a radiological incident at a DOE or NRC licensed facility. Specifically, under the agreement with NRC, EPA will be notified in a timely manner of releases of radiological effluents resulting from specified situations. The agreement with DOE has similar provisions, under which EPA will be notified of accidental radioactive releases to the environment which must be reported to DOE headquarters.

EPA maintained emergency response team capability at headquarters and at the laboratories in Montgomery, Alabama, and Las Vegas, Nevada. Similar arrangements have been made by BRH, both at headquarters and field facilities, and by DOE at their major nuclear laboratories. The teams would provide technical and laboratory services on request to State agencies responding to an accident, as set forth in the Interagency Radiological Assistance Plan.

International Activities

During 1977 EPA and NRC participated in an International Atomic Energy Agency (IAEA) effort to develop international guidance on plans for response to major radiological accidents. This effort is continuing, and a draft report from IAEA should be available in 1978.

DOE Activities

DOE expanded the Atmospheric Release Advisory Capability, a computer technique which projects dose on the basis of environmental data collected following a release. The Capability achieved operational status during working hours and was used to evaluate the potential consequences of a railroad accident near Rockingham, N.C. Although the accident, which involved some nuclear material, did not result in any releases to the atmosphere, the test proved the responsiveness of the system.

V. OTHER NUCLEAR SOURCES

• Nuclear Weapons Testing

The Treaty on the Limitation of Underground Nuclear Weapon Tests, commonly known as the Threshold Test Ban Treaty, and its companion Treaty on Underground Nuclear Explosions for Peaceful Purposes have been signed and introduced to the U.S. Senate for ratification. These treaties limit individual underground nuclear tests to 150 KT. In the interim, pending their entry into force, the United States has announced its intention to abide by the yield limits of the treaties. However, the capability to conduct larger nuclear tests at the Nevada Test Site (NTS) remains unchanged.

Since the 1963 Limited Test Ban Treaty, DOE and its predecessors (the Atomic Energy Commission and ERDA) have conducted underground nuclear tests to support (1) national laboratories' development of weapons in response to Department of Defense requirements, and, in previous years, (2) DOE's development of explosives for peaceful applications.

Each test is reviewed in advance by a Containment Evaluation Panel of experts drawn from the Los Alamos Scientific Laboratory, the Department of Defense, the U.S. Geological Survey, the Sandia Laboratories, and the Lawrence Livermore Laboratory. The Panel considers many factors which could contribute to atmospheric discharges, such as device yield, hydrology, closure methods, and drilling and construction histories.

During the test itself and on the day before the test, a Test Controller's Advisory Panel is convened to advise on possible effects. Mobile monitors are sent to areas downwind of the detonation to monitor possible releases, and aerial surveillance is conducted above the site itself to track any radioactive clouds.

Announced U.S. nuclear detonations during 1977 are shown in Table 5.1.

Table 5.1
ANNOUNCED U.S. NUCLEAR DETONATIONS
1977

	Date (GCT) (D/M/Y)	TYPE	YIELD
Marsilly	5/4/77	Underground	20 — 150 Kilotons
Bulkhead	27/4/77	Underground	20 — 150 Kilotons
Crewline	25/5/77	Underground	20 — 150 Kilotons
Strake	4/8/77	Underground	20 — 150 Kilotons
Scantling	19/8/77	Underground	20 — 150 Kilotons
Ebbtide	15/9/77	Underground	20 — 150 Kilotons
Coulommiers	27/9/77	Underground	20 — 150 Kilotons
Bobstay	26/10/77	Underground	Less than 20 Kilotons
Hyola Gold	01/11/77	Underground	Less than 20 Kilotons
Sandreef	09/11/77	Underground	20 — 150 Kilotons
Seamount	17/11/77	Underground	Less than 20 Kilotons
Farallones	14/12/77	Underground	20 — 150 Kilotons

Tests During 1977

On September 17, 1977, the People's Republic of China detonated a nuclear device with an estimated yield of less than 20,000 tons of TNT equivalent, at the Lop Nor test in northwest China. Since the test was above ground, large amounts of radioactive materials were dispersed into the atmosphere. The contaminated air mass passed over U.S. territory during the week of September 18.

Before the air mass reached the U.S., EPA/ORP activated 45 additional standby air particulate and precipitation sampling stations, as well as increasing sampling frequencies for the 22 air sampling stations normally operated. They are part of the Environmental Radiation Ambient Monitoring System (ERAMS). The air particulate samples were used to estimate the potential inhalation dose to the U.S. population, and precipitation samples were collected to indicate rainout of radioactive materials. Particular emphasis was placed on sampling pasteurized milk, since the most critical pathway for potential exposures to fallout contamination is due to deposition of iodine-131 and strontium-89 on pasture grass and ingestion by cows. Iodine is of special concern because it concentrates in human thyroids.

EPA/ORP's special monitoring of the concentrations of radioactivity in air particulates, precipitation, and milk continued until the concentrations returned to normal in November. The program included the collection of 472 pasteurized milk samples, 1119 air particulate samples, and 97 precipitation samples. As a result, over 3000 radiation measurements were made at EPA's Eastern Environmental Radiation Facility in Montgomery, Alabama.

ERAMS data indicated that peak radioactivity concentrations in both air and milk were lower than those encountered after the two 1976 Chinese detonations. However, elevated concentrations were more widespread geographically and continued for a longer time. They were first observed in air on September 25, and continued to be reported through September 29. The first indications of iodine-131 in pasteurized milk were in samples collected September 23; the concentrations generally increased through the weeks of October 3 and 10, and then decreased until reaching nearly normal values in the week of October 31. An assessment report of the 1977 fallout is in preparation. It will provide a description of EPA's monitoring system, its response to the fallout situation, monitoring program results, and estimates of population radiation dose and potential health effects.

During the fallout period, EPA issued fifteen news releases, first forecasting the trajectory of radioactive debris in the atmosphere and announcing activation of ERAMS, then later interpreting the results of its monitoring programs. Much of the information, particularly for the earlier news releases, was provided by the National Oceanic and Atmospheric Administration and DOE.

Tests During 1976

Following up on the September 26 and November 17, 1976, Chinese tests, an assessment of the resulting fallout was published in August 1977. The ^{131}I-milk-thyroid pathway was reported as most important, since others produced less dose by a factor of at least 7.5. (See Strong, A.B., Smith, J.M., and R.H. Johnson, "EPA Assessment of Fallout in the U.S. from Atmospheric Nuclear Testing on September 26 and November 17, 1976 by the People's Republic of China," EPA: EPA 520/5-77-002 (August 1977).) The other pathway evaluations included nuclides other than ^{131}I in milk, direct radiation from the air and ground deposition, inhalation of contaminated air, and ingestion of contaminated water.

Radiation levels following the November detonation were too low for meaningful calculation of health effects.

Federal Responses to Nuclear Detonations

EPA/ORP took the lead in developing a Memorandum of Understanding to assure coordination among Federal agencies in the collection and dissemination of information regarding potential radioactive contamination from foreign nuclear detonations. The Memorandum identifies and establishes responsibilities and interactions of the seven Federal agencies concerned with monitoring radioactive contamination and protecting the public from adverse effects. The Memorandum deals with two types of response conditions: the first concerns the movement of contaminated air masses over the United States and possible effects at ground level due to dry fallout or rainout of radioactive debris. The second type concerns civil aircraft flights which may pass through contaminated air masses at various altitudes. Although the Memorandum has not been finalized and signed, all operational elements are in place and functioning.

Environmental Impact Statement

Nevada Test Site

Description: ERDA prepared a Draft Environmental Statement on the continuation of its underground testing program and other activities at the Nevada Test Site for Fiscal Year 1978 and beyond (ERDA-1551-D). It addresses environmental consequences that may not have been fully evaluated when the first basic Statement was issued in 1975, and serves as a base for evaluating the impact of future actions in relation to the existing environment.

EPA/ORP Response and Status: Given the requirement for testing, EPA/ORP concluded that the proposed program can be conducted with an acceptable environmental impact, and that the Draft adequately evaluates it. In that context, additional information on the radiation guidance used for the site was requested, especially with respect to off-site populations under normal operating conditions, as well as emergency or accident circumstances. It was suggested that the Final Statement include the rationale or basis for ERDA's test criteria, a much more detailed evaluation of the potential doses resulting from test accidents, and an assessment of the likelihood of the accidents themselves.

Studies

Aircrew Performance

The Air Force conducts a research program to define aircrew performance problems and exposure limits to ionizing radiation predicted to be received during air operations in a nuclear war. The Army program's objective is to develop a chemical means of protecting against the effects of ionizing radiation, using studies on synthesis of appropriate structures and human tolerance to them. In addition, the usefulness of chemical protection was investigated, and ad hoc committees looked at different aspects of the therapy of radiation injury.

Atomic Bomb Survivors

The National Cancer Institute continued to analyze information concerning the survivors of the 1945 A-bomb explosions. New cancers (lymphomas and cancers of the esophagus, stomach, and urinary tract) were added to the list of those known to be caused by ionizing radiation from the explosions, and solid tumors were found to outweigh leukemia in terms of absolute risk. The data do not support a non-specific aging effect; cancer is clearly the major late effect. Studies of breast cancer revealed a dose response relationship that was approximately linear (i.e. response was in direct proportion to dose) at low doses, with an effect at doses as low as 17 rad. Latency for both breast and lung cancer was unaffected by dose, while leukemia tended to occur earlier in the heavily exposed groups. However, the mechanisms for inducing leukemia may be fundamentally different from carcinogenesis generally.

2. Defense Wastes

Preparatory to the issuance of environmental impact statements, ERDA compiled technical Defense Waste Documents (DWD's) on alternative methods for long-term management of high-level radioactive wastes generated as part of the defense program at three ERDA sites. They describe the current technological status and anticipated costs and risks of all reasonably available waste forms and storage modes for the Hanford Reservation near Richland, Washington; the Savannah River Plant near Aiken, S.C.; and the Idaho National Engineering Laboratory (INEL) near Idaho Falls, Idaho. These documents will serve as pertinent background information for Draft Environmental Impact Statements for dealing with the wastes at the three sites.

EPA/ORP expressed strong objections to "Alternatives for Long-Term Management of Defense High-Level Radioactive Waste at the Savannah River Plant, Aiken, S.C." (ERDA 77-41/1,2). The Agency noted that there are serious uncertainties about the potential impact of disposing of high-level waste in bedrock, a method involved in three of the eight alternatives ERDA considered in detail. The Agency reiterated the problems discussed in its comments on the Savannah River Draft Environmental Statement, which are detailed above under Wastes in the Nuclear Power chapter.

EPA/ORP reviewed ERDA's Defense Waste Document entitled "Alternatives for Long-Term Management of Defense High-Level Radioactive Waste, Hanford Reservation, Richland, Washington." It presents pertinent background information for preparing a Draft Environmental Statement relating to establishing an environmentally acceptable mode of disposal for the Hanford wastes. Four basic alternatives with variations are discussed, ranging from continuing the storage as salt cake and sludge in tanks (the "no action" alternative) to conversion of the waste to a glass form and shipping it to a Federal repository. In EPA's view, several of the alternatives are not ultimate disposal options, but should be considered at best to be interim storage. The Agency also felt that the 50-year dose commitment (see glossary) used in the document is not acceptable to describe the impact of the activity on future generations.

The comparable document for the Idaho National Engineering Laboratory was also reviewed by EPA/ORP, with similar conclusions. (See "Alternatives for Long-Term Management of Defense High-Level Radioactive Waste, Idaho Chemical Processing Plant, Idaho Falls, Idaho," ERDA 77-43.) While some of the alternatives examined in the report included ultimate disposition, the Agency did not feel it adequately covered the relationship between long-term management or storage and ultimate disposition, or the timing of the change from storage to disposal phase. Also, the use of 50-year dose commitment was not considered acceptable to describe the impact of the activity on future generations. A thorough examination of the objectives of the program was suggested, along with consideration of the forthcoming EPA criteria.

Environmental Impact Statement

Rocky Flats Plant Sites

Description: ERDA's Draft Environmental Statement on the "Rocky Flats Plant Site, Golden, Colorado," was issued as ERDA-1545-D. The facility of greatest concern on the site is a plutonium plant used for nuclear weapons production, located about 16 miles from Denver. In its Statement, ERDA addressed a broad range of possible effects of the operation, but focused primarily on the radiation impacts.

EPA Response and Status: EPA rated the Draft environmental reservations/insufficient information. Among the major criticisms was that the Draft considered whole-body dose instead of internal exposures, which are more significant in terms of the kind of materials handled at Rocky Flats. EPA/ORP also commented that the decontamination costs were greatly overestimated of complying with the Colorado State Department of Health standard regarding plutonium soil contamination. In addition, the estimates of public health impacts did not treat local impacts adequately. They should have included calculation of maximum individual dose, population dose, and environmental dose commitment.

3. United States Nuclear Navy

At the end of 1976, the Navy was operating 107 nuclear submarines and 8 nuclear-powered surface ships. Support facilities involved in construction, maintenance, overhaul and refueling of these vessels include 9 shipyards, 13 tenders, and 2 submarine bases.

Within 12 miles of shore, less than 0.002 curies of long-lived gamma radioactivity were released annually by the nuclear Navy from 1972 to 1976. (This figure includes all nuclear-powered ships and the ports they visited, as well as supporting facilities.) Most tritium released was beyond 12 miles from shore, a total of less than 200 curies. Not including tritium, the radioactivity released at sea was about 0.4 curies in 1976. Solid radioactive wastes from the Navy are packaged and shipped to licensed burial sites in compliance with NRC and Department of Transportation standards. In 1976, about 53,000 cubic feet and about 92 curies were disposed of.

The Navy concluded in their annual environmental report that radioactivity associated with their nuclear program has had no significant or discernible effect on the quality of the environment. (See "Environmental Monitoring and Disposal of Radioactive Wastes from U.S. Naval Nuclear Powered Ships and Their Support Facilities," Naval Sea Systems Command Report NT-78-1 (February 1978).)

Radiological Surveys of Ports

EPA's Eastern Environmental Radiation Facility, in cooperation with the U.S. Naval Ship Systems Command, conducted a study of the Portsmouth Naval Shipyard in the summer of 1977. The purposes were to locate, identify, and measure any radionuclides present in the port and environs from nuclear ship activity, and to assess the significance of any exposure to the general population in the vicinity. While pursuing these goals, the study also evaluated the adequacy of the Navy radiological controls and monitoring program. Reports on both of these evaluations are in preparation and should be completed in 1978.

4. Consumer Products

Education and Quality Assurance

BRH, EPA, and NRC cosponsored an international Symposium on Radioactivity in Consumer Products in February 1977 at the Georgia Institute of Technology. It included over 100 representatives of the scientific community, State and Federal agencies, domestic and foreign industries, and consumer groups. The Symposium provided a forum for the exchange of information, and reviewed the type and extent of radioactive material used in consumer products, the potential health hazards associated with their manufacture and use, and governmental activities in the area.

Studies

A variety of articles containing small quantities of byproduct and source materials are distributed to the public. Recently, there has been a rapid growth in the distribution of ionization-type smoke detectors containing americium 241 and backlit digital watches containing tritium. Such products are distributed in accordance with criteria published in 1965. Because Federal statutory responsibilities (i.e., NEPA) have changed since these criteria were established, the NRC is initiating a two-year study to determine the environmental impact of the distribution of consumer products containing radioactive materials and whether changes are necessary in the criteria. A generic environmental impact statement will be issued at the conclusion of the study.

VI. PROTECTION FROM NONIONIZING RADIATION

1. Introduction and Summary

Although environmental levels of nonionizing radiation were negligible before the 1930's, virtually every American is now exposed. Sources have proliferated in number as well as power; in the ranges of primary interest, the radiofrequency (10 MHz to 300 MHz) and microwave (300 MHz to 300 GHz) frequencies, the environmentally significant sources include:

— radio and television broadcast stations

— radars

— satellite communications system earth terminals

— point to point microwave communications

— mobile communications systems

— microwave ovens

— industrial heating equipment.

Other nonionizing radiation sources are lasers that produce radiation ranging in frequency from the ultraviolet through the far infrared and overhead extra-high voltage power lines.

Quantum energies associated with microwave radiation at its extreme of 300 GHz are about 8000 times less than is needed to destroy cells by ionization; however, radiofrequency and microwave radiation do get absorbed by tissue and do interact with biological systems. The electromagnetic energy is transformed into increased kinetic energy of the absorbing molecules, and results in tissue heating. The process of absorption and distribution in irradiated tissue depends on the radiation wavelength and its relationship to the physical shape, size and distribution of a nonuniform system of tissues, the electrical characteristics of tissue at specific frequencies, and the intensity of the radiation.[1] [2] A complex tissue structure such as the human body absorbs energy differently in specific parts, so that localized heating or nonuniform absorption may result.

Two kinds of effects on humans due to exposure to radiofrequency and microwave frequency radiation are usually discussed: thermal effects from high-level exposures, and possible low-level or "nonthermal" effects.

Thermal effects, resulting from irradiation with power densities above 10,000 microwatts/square centimeter (abbreviated as μ W/cm^2, and equivalent to ten milliwatts/cm^2 or mW/cm^2), involve tissue heating with the possibility of thermal damage. They may include increased body temperature and resulting heat stress, cataract formation, cardiovascular effects, testicular effects, and brainwave pattern changes.[3]

Low-level effects are a subject of controversy. Effects of exposure to 1,000 μ W/cm^2 (one mW/cm^2) or less have not been well documented; in fact, all U.S. scientists do not even agree that they exist. Some Russian and Czech scientists believe that they occur, but not as a result of increased tissue temperature (hence "nonthermal" effects). Their views are based on animal research and statistical studies of workers' exposure histories and medical records. Considered to be mainly central nervous system effects, symptoms attributed to low-level exposure include headache, weariness, dizziness, irritability, emotional instability, partial loss of memory, loss of appetite, cardiovascular effects, electroencephalogram changes, blood chemistry changes, changes in respiration, and possible genetic effects.[4]

1. Gandhi, O.P. and K. Sedigh, "Biological Phantom Materials for Simulating Man at Different Frequencies." Presented at the USNC/URSI 1976 Annual Meeting, Amherst, MA (October 10–15, 1976).

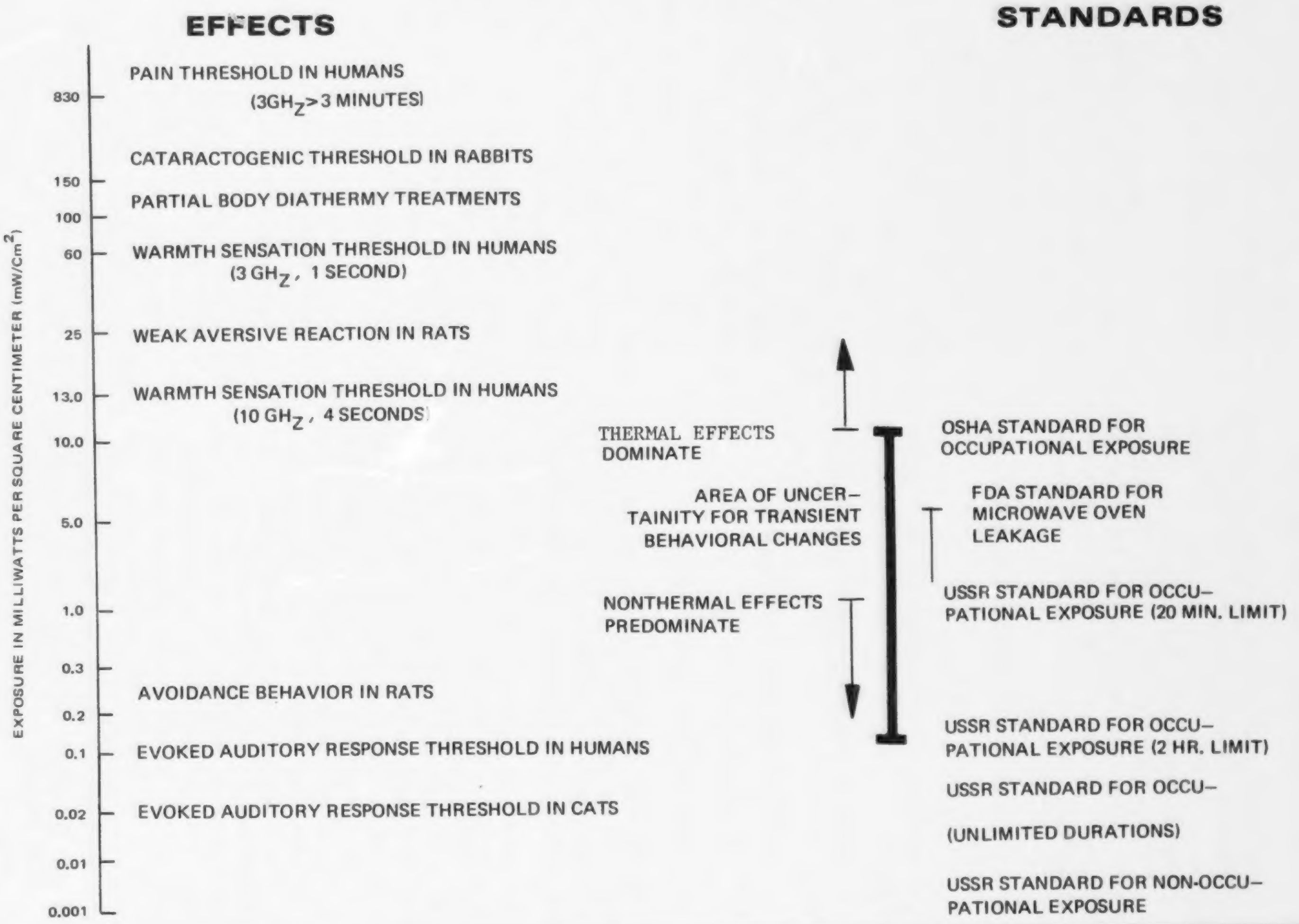
2. Wallace, J.E. and A.W. Guy, "Experimental Heating Patterns in Bi-Layered Biological Tissue Circular Aperture Sources." Presented at the USNC/URSI 1976 Annual Meeting, Amherst, MA (October 10–15, 1976).

3. Cleary, Stephen F., "Uncertainties in the Evaluation of the Biological Effects of Microwave and Radiofrequency Radiation." *Health Physics* 25:387–404 (October 1973).

4. Pressman, A.S., "Electromagnetic Fields and Life." Plenum Press, New York (1970).

TABLE 6.1

NONIONIZING RADIATION



While American scientists are skeptical of behavioral data and the conclusions of the Eastern European experts, there has been little research conducted in the U.S. involving long term exposures to low-level microwave and radiofrequency radiation intensities, even in animal experimentation. Some U.S. scientists believe that the effects observed, if real, could result from non-uniform energy distributions and very small localized temperature changes in the body, where the structure of certain molecular systems may be changed in some minor, reversible way.

The exposure limits in protective standards differ widely among various countries. In Eastern Europe, they are geared to protect against "non-thermal effects" of long term exposure to low intensity radiation. On the other hand, in the U.S. and most Western European countries, standards were designed with high level exposures and possible thermal effects in mind. Below are summarized both occupational and environmental exposure limits for the USSR, Czechoslovakia, Poland and the U.S. in simplified form.

The occupational exposure standards of the world generally fall into three groups on the basis of their exposure limits. The most conservative group includes the USSR and Czechoslovakia, with limits in the range of tens of μ W/cm^2. In the middle group are the standards of Poland, Sweden, the Bell Telephone Company, and the N.V. Phillips Company (Netherlands), with limits in the range of hundreds of μW/cm^2 up to about 1000 μW/cm^2. The U.S. and most of Western Europe have standards in the most permissive group.

In the U.S. the principal occupational standard is the American National Standards Institute's (ANSI), which was reaffirmed with minor changes in 1974. The Defense Department has had a similar standard since about 1953; the Air Force recently adopted a value of 50 mW/cm^2, or 50,000 W/cm^2, for frequencies between one kHz and ten MHz, where previously there had been no standards. In 1971 the Occupational Safety and Health Administration adopted the 1966 version of the ANSI standard as a national consensus standard. It recommends allowable limits of 10,000 μW/cm^2 for periods of 0.1 hours or more for frequencies from ten MHz to 100 GHz, with more intense exposures being allowed for shorter time periods. (See C.F.R., Title 29—Labor, Part 1910.97.) According to a December 31, 1975 decision, the OSHA standard is considered to be advisory rather than mandatory. In contrast, the USSR occupational exposures allowed for the 300 MHz–300 GHz frequency range cannot exceed 10 μW/cm^2 for the duration of a working day, although greater exposures are allowed for short periods of time.

NONIONIZING RADIATION STANDARDS (SIMPLIFIED)

Occupational Exposure (μW/cm^2)

	USSR	Czech.	Poland	U.S. ANSI (advisory)
Above 300 MHz	10	25	200	10,000
30–300 MHz	6	25	106	10,000

Environmental Exposure (μW/cm^2)

	USSR	Czech.	Poland	U.S.
Above 300 MHz	1	2.5	10	(none)
30–300 MHz	1	.25	13	(none)

There are no general public health or environmental standards for microwaves in the U.S. (Other countries have typically set such levels about a factor of ten more restrictive than their occupational standards.) However, the U.S. does have a microwave oven performance standard, which limits the permissible microwave radiation leakage from the device itself, rather than the maximum level to which an individual might be exposed. The limit for new ovens is 1000 μ W/cm^2, measured at any point five centimeters from the surface of the oven. Ovens in service may degrade to levels no greater than 5000 μW/cm^2 at the same distance. Although not directly comparable to the exposure standard, the microwave oven limits should probably be considered with the most restrictive group.

Summary

Comprehensive

Before it was reorganized, the Office of Telecommunciations Policy coordinated, overviewed, and provided a central focus for the Federal Government program concerned with research, regulatory and other activities involving the biological effects of nonionizing radiation.

Radiofrequency and Microwave

BRH solicited comments on the clinical implications of a draft performance standard for microwave diathermy equipment, implemented streamlined procedures for monitoring reports submitted by television manufacturers, and reviewed future plans to assure the radiation safety of sunlamps. Ultraviolet radiation hazard monitors were also being developed as prototypes.

EPA studies included urban environmental measurements, and investigations of the efects of irradiation on length of gestation, behavior, and other factors in animals; the relationship between ultraviolet radiation and skin cancer was also researched, as well as thermal considerations. Analyses were made of the environmental impacts of the Pave Paws radar systems.

BRH conducted a review of its research programs, which included a study of microwave diathermy applicators and microwave-induced behavioral changes. A patent was assigned for an ultraviolet radiant energy monitor, and a miniature electromagnetic probe system was developed by BRH engineers.

The National Institute of Environmental Health Sciences conducted studies to develop systems with well characterized microwave fields, and instruments and techniques which can measure energy deposited in a system accurately and without disturbing it.

The Department of Defense has an extensive research program, pursuant to a comprehensive Tri-Service plan. The Army's emphasis has been establishing the existence of bioeffects of microwave radiation and understanding the biological mechanisms on which they are based, while the Navy program has stressed criteria to help establish standards to protect people in the naval environment. The Air Force's efforts are directed at describing how radiofrequency radiation is distributed in biological organisms.

Light Products and Devices

BRH began developing a standard for mercury vapor lamps, and sent warning notices concerning them to 68,000 consumers and designers. A proposed standard for sunlamps was published in the *Federal Register*.

High Voltage Transmission Lines

A contract was awarded by EPA to summarize comments received on health and environmental effects of EHV power transmission.

Lasers

BRH granted the first variance from the Federal laser product performance standard for a laser system designed for surveying applications. The Army conducted a number of relevant animal studies.

Executive Activities

a. Comprehensive

As part of its responsibilities, the Office of Telecommunications Policy (OTP) in the Executive Office of the President coordinated, overviewed and provided a central focus for the Federal Government program concerned with the biological effects of nonionizing radio-frequency and microwave radiation (0-300 GHz). The program includes individually funded efforts of agencies with relevant responsibilities for radio-frequency and microwave use, regulation, research, and/or health and the environment. A principal objective is to develop a sound scientific basis for assessing effects and for developing rational guidelines or regulations to ensure the safe and effective use of the radio and microwave spectrum in the full public interest.

With the advice of the Electromagnetic Radiation Management Advisory Council (ERMAC), an expert panel which recommended the Federal program in 1971, and the assistance of an interagency working group for intragovernmental coordination, OTP reviewed progress and ongoing efforts and provided general guidance and recommendations.

During 1977 OTP/ERMAC continued to conduct technical seminars in key research areas. A principal undertaking was a series of comprehensive reviews of Agency programs over the past 5 years, to evaluate current status, funding/resources, research highlights and future plans as a basis for assessing progress and determining future research and funding requirements. These activities were open to all interested parties and were widely attended by the government and scientific communities. Summaries are available and additional information can be found in previous OTP reports on the Federal program in this area. OTP continued to update and make available a comprehensive, full-text computerized information system of relevant world literature. Information can be remotely accessed via telephone lines from any compatible terminal. (A digest containing abstracts of this literature and other information on this subject is published quarterly in hard copy form and is available through the National Technical Information Service, Department of Commerce.)

As a result of Reorganization Plan No. 1 of 1977, OTP was abolished in early 1978 and the majority of its responsibilities, including this function, were reassigned to a new entity, the National Telecommunications and Information Administration, established within the Department of Commerce.

Radiofrequency and Microwave

Guidance

Draft Standard for Microwave Diathermy Products

BRH convened a public meeting to solicit comments on the clinical implications of the draft performance standard for microwave diathermy equipment. Attendees indicated their general acceptance of the present draft, but suggested a change that would restate the requirement concerning the heating ability of the applicator. The Agency concurred with the proposed change and is studying ways of incorporating the requirements into the draft and integrating it with the specified leakage limit. Once the standard has been redrafted to incorporate the suggested change, it will be published in the *Federal Register* as a proposed rule.

Compliance

Monitoring Reports by TV Receiver Manufacturers

BRH has implemented streamlined procedures for monitoring reports submitted by television manufacturers in accordance with Radiation Control Act requirements. These have improved the Agency's capability for handling large numbers of reports and identifying potential cases of non-compliance with the television performance standard. The procedures, in addition to establishing priorities for report review, are designed to assure that no report goes unaddressed for more than 60 days, thus holding the backlog of reports to a minimum. During the past 15 months the number of reports reviewed has increased 570 percent and the backlog has been cut in half.

To provide further assurance of compliance with the standard, report review activities are combined with inspections of manufacturing plants and laboratory testing.

Sunlamps with Faulty Timers

The General Electric Company recalled all model RSK6 "Time-a-Tan Suntanner" kits manufactured between January and March 1977, because faulty timers in some units could fail to switch off the sunlamp at the preset time. Production and distribution were suspended, and BRH revised future plans to assure the radiation safety of the sunlamps.

UV Hazard Monitor

BRH has awarded a contract for the development, construction, and testing of three ultraviolet radiation hazard monitors. The units are to serve as prototypes for production models of a portable, easy-to-operate, relatively inexpensive instrument that can provide a direct readout of the health hazards from various sources of ultraviolet radiation, such as sunlamps, laser pump sources, germicidal lamps, and high-pressure gas-discharge lamps.

EPA Studies

Urban Environmental Measurements

As part of its program to determine the need for standards to control environmental non-ionizing radiation exposure, EPA/ORP began measuring urban area environmental radiofrequency (RF) and microwave radiation levels in Boston and Atlanta in 1975. The study continued in 1976 with the completion of measurements in Miami, Philadelphia, New York, Chicago, and Washington, D.C. Three new cities were added in 1977, Las Vegas, San Diego and Portland, Oregon, bringing the total population covered to about 30 million. Cumulative exposure from all the cities studied was .0656 $\mu W/cm^2$, with an extreme high value of 152 $\mu W/cm^2$ in a residential neighborhood.

Length of Gestation

EPA is investigating the effects of chronic irradiation of mice at 2450 MHz on the length of gestation, since a pilot study indicated a significant lengthening of the duration of pregnancy. Also, a large number of mouse litters have been examined for teratological changes after daily irradiation in utero at 2450 MHz. Three exposure levels (3500; 14,000 and 28,000 $\mu W/cm^2$) were used, and a total of seven encephaloceles (hernias of the brain) were found in approximately 300 litters (3000 animals); no such anomalies were found in a similar number of controls. The normal incidence of this anomaly is three in 10,000. The significance of the results is being evaluated.

Animal Studies on Behavioral Effects

Several EPA behavioral studies are in progress for both acute and chronic irradiation of rats or squirrel monkeys. Subjects being investigated include changes in social behavior, in stress-related biochemical substances, EEG parameters, and performance after operant conditioning. Results from one such 1976 study show that rats irradiated (15,000 and 20,000 $\mu W/cm^2$, 2450 MHz) for 15 hours display at least a 40% decrease in task performance whereas one hour exposures show no decrease. Lower powers did not produce statistically significant decreases in behavior after 15 hours of exposure, but the trend toward lowered performance was seen at power densities as low as five mW/cm^2.

These types of studies were continued in 1977, to quantify more precisely the relative effects of different densities and environmental temperatures during exposure, in terms of behavioral changes measured after termination of exposure. The conclusion concerns schedule-controlled behavior for food reinforcement which decreases after microwave exposure. It was found to decrease even more when higher air temperatures existed during exposure, over a range common in the environment.

A chronic study of behavioral effects is being performed at Stanford Research Institute. Pregnant squirrel monkeys are being exposed throughout gestation to 2450 MHz radiation, three hours per day, five days per week. Infants will be exposed on the same schedule to 12 months after birth. (Exposure levels are 100; 1000 and 10,000 $\mu W/cm^2$.) In addition to behavioral responses, biochemical and immunological parameters are being investigated. Exposures have been completed, as well as autopsies on some animals in the higher exposure level groups who died unexpectedly. Results from both are being evaluated.

In Vitro *Studies*

EPA's *in vitro* work in progress is concentrating on the study of amplitude modulated microwave radiation on the normal processes of enzyme systems, bacterial and mammalian cells, and brain tissue. Among the specific studies is one in which enzyme systems have been irradiated in an exposure system where enzyme activity was measured during irradiation. No statistically significant differences in enzyme activities were observed between irradiated and control samples at any modulation frequency. In another study, exposure of isolated rat gut did not produce a measurable effect on the spontaneous contraction rate of smooth muscle. No significant changes were observed in mice repeatedly exposed to 2450 megahertz when they were investigated for effects on hematology and lymphocyte function.

EPA also verified and extended reports in the literature of changes in calcium binding to the surface of the brain during exposure to nonionizing electromagnetic radiation. It was found that the effect appeared at some frequencies and power densities while not at others.

UV Radiation and Skin Cancer

Along with the National Cancer Institute, EPA initiated a study to clarify the role of solar UV radiation in the development of non-melanoma skin cancer, by means of a demographic survey using SEER tumor registries around the country, and a case-control study to clarify the influence of various host and environmental factors.

Analysis of Thermal Considerations

EPA conducted an analysis of existing radiofrequency and microwave radiation absorption data to examine the frequency-dependent phenomenon of biological tissue heating. Restricted to thermal considerations, the analysis examined the exposure field intensities associated with various levels of thermal loading on the body as a whole and on specific, selectively absorbing tissues in adult humans and infants. When the final report is published in 1978, it will discuss the results in terms of their implications for existing U.S. and Soviet safety standards and for typically encountered exposures in the United States.

Environmental Impact Analysis of Radar Systems

In response to a Congressional request, EPA/ORP conducted analyses of the environmental impacts of the Pave Paws radar systems on the basis of microwave radiation alone. Both systems were designed to detect and track sea launched ballistic missiles. For the proposed facility near Yuba City, California, EPA found that Air Force calculations of environmental microwave exposure levels were based on very conservative assumptions. It appeared unlikely to the Agency that exposures produced beyond the base boundaries could cause health effects. The other facility, at Otis Air Force Base, Massachusetts, was assessed with similar results; however, the public would have access to the base through a road that might be constructed in the future, and there is a possibility that peak field intensities there have the potential of interfering with heart pacemakers.

BRH Studies

Review of Research Programs

The Agency's current in-house and extramural activities in the area of microwave and radiofrequency research were reviewed at a Bureau-sponsored symposium, February 16-18, in Rockville. More than 120 persons, including representatives of federal and state agencies, industry, and the news media attended.

The purpose of the meeting was to bring together bureau contractors, grantees, and headquarters personnel to exchange information on their research and to review the status of ongoing projects. Among the topics discussed were the biological effects of animal exposure to various levels of microwave radiation, measurement instrumentation and techniques, and the health implications of occupational exposure.

The symposium was the second in a series being convened by the Bureau to review its major program areas. The first, which covered the biological effects and measurement of light sources, was held in March 1976.

Microwave Diathermy Applicators

A BRH conducted study of microwave diathermy applicators has shown that unnecessary radiation exposure can be more easily controlled with the new direct-contract applicators than with the conventional spaced ones presently in general clinical use. The older applicators can cause scattered as well as radiated energy to impinge on the operator and on unprescribed patient tissue. One way of minimizing the hazard is to use appropriate shielding, but that is a rather cumbersome method. The new models minimize the possibility of scattered radiation because they are applied directly to the patient's skin.

Microwave-Induced Behavioral Changes

A BRH study has demonstrated, under certain conditions, that exposure to microwave radiation may alter the behavior of laboratory animals. In three separate experiments, scientists investigated (1) the behavioral changes induced by the interaction of microwaves and a neuroactive drug, (2) the stimulus properties of microwaves as a conditioning agent to produce an acquired taste aversion, and (3) the possibility of using microwaves as a conditioning agent to produce an acquired taste aversion.

Prototype UV Hazard Monitor

A patent has been assigned for an ultraviolet radiant energy monitor that can give a direct readout of the health hazards from sources of incoherent, broadband optical radiation. The device was designed by BRH scientists to fill the need for a portable, simple, and relatively inexpensive instrument that can be used for field measurements of emissions from such light-emitting products as sunlamps, germicidal lamps, laser pump sources, and high-pressure gas-discharge lamps.

Miniature Electromagnetic Probe

To meet the needs of researchers investigating the biological effects of electronic product emissions in the range of 0.2 to 12 gigahertz, BRH engineers have developed a miniature electromagnetic probe system. Its accuracy, small size, and fiber optic telemetry system make it a valuable tool for laboratory measurements where present probes are not appropriate because of their physical size or hard-wired readout. The Bureau has already used the probe to study scattering and field distributions near Plexiglass animal holders during microwave bioeffects experiments.

National Institute of Environmental Health Sciences (NIEHS) Studies

The objectives of the NIEHS nonionizing radiation research program are:

— to develop microwave exposure systems for bioeffects research

— to develop and test techniques for measuring microwave energy absorption

— to determine the effect of microwaves on isolated nerve preparations

— to determine how 2450 MHz microwave radiation interacts with biological systems at all levels

— to study the effect of long-term exposure of experimental animals to 915 MHz and 2450 MHz microwave radiation on their central nervous system and behavior

— to ascertain the effect of 60 Hz fields from high voltage transmission lines to the central nervous system of mammals.

The Institute has conducted a number of studies to fulfill these objectives. Specificially, because it is important to know the dose of the exposure in order to correlate the incident exposure to the absorbed energy, NIEHS scientists have developed systems with well characterized microwave fields. A refinement of the system is that the biological specimen is located inside environmental chambers which allow control of temperature and humidity during irradiation, so electromagnetic field effects can be separated from gross heating of the specimens. In order to correlate any biological effect with absorbed microwave energy, it is important to characterize correctly the amount of energy that the biological system is exposed to. NIEHS has developed instruments and techniques which can measure energy deposited in a system accurately and without disturbing it.

DOD Studies

The Department of Defense has an extensive research program on nonionizing radiation, pursuant to a comprehensive Tri-Service plan developed in 1974-76. The Army's activities have been concerned primarily with establishing the existence of bioeffects of microwave radiation, and the elaboration of the biologic mechanisms on which they are based, so that rational safety standards can be established. The general strategy is first to identify effects and their limits, examine biological mechanisms, and determine the medical hazard represented. Five program blocks have resulted from the strategy: energy distribution and measurement, biophysical actions of microwaves, bioeffects of pulsed radiation, behavioral and other studies, and the extramural program. Program accomplishments to date include:

— development of a rational management strategy for research to determine potential microwave hazards,

— establishment of methods to measure tissue microwave properties,

— development of methods for precise, continuous measurement of temperature changes in the organs of exposed subject animals,

— establishment of the feasibility of nonsurgical methods for measuring microwave energy deposition by complex computer analysis, with further development in process,

— demonstration of microwave effects on basic biological processes,

— reports of the unique hazards of exposure to pulsed microwave radiation, as compared to continuous microwave exposure of the same frequency and average power,

— identification of behavioral effects of exposure,

— demonstration of the importance of antenna-like properties of animals and their organs,

— conclusion that there is no unique association between occupational microwave exposure and cataract formation, and

— identification of new potentially beneficial applications of microwaves.

The Navy program concerns both microwaves and the extremely low frequency area. In the latter, research has explored a wide range of fields, including physiology, behavior, biological rhythms and human performance. The goal of the microwave program is to develop criteria for use in the establishment of standards, limitations and design guidelines intended to protect personnel in the naval environment and the relevant public. Fundamental research is continuing to determine whether other than thermal mechanisms can account for observed effects. Simultaneously, a pragmatic approach has been taken to five separate areas of concern:

— central nervous system, including histological changes, alternations in the blood brain barrier, and changes in other parameters,

— behavior, particularly cognitive, perceptual motor, and vigilance performance,

— immunology/hematology,

— dosimetry and energy distribution, covering the influence of peak powers and pulse shapes, and the influence of electric versus magnetic fields in contributing to observed effects.

The Air Force's efforts are directed at a series of studies to describe how radiofrequency radiation is distributed in biological organisms. They show conclusively that the effect of RF radiation on biological systems is dependent not only on the magnitude of the exposure level but also on the frequency of the radiated energy, as well as on the size and orientation of the organisms in relation to the emitter. A major project has been developing and updating a dosimetry handbook for the use of all investigators, which has been distributed both in the U.S. and in Europe to a very favorable initial response. Additional test data were actively solicited for inclusion in the second edition, published in early 1978. Continuing studies are being made of the effects on the central nervous system, immune system, and behavior.

c. Light Products and Devices

Guidance

Standard for Mercury Vapor Lamps

BRH began development of a radiation safety performance standard for mercury vapor lamps, which would permit the manufacture of two types of lamps. The first would have an extinguishing device that causes shut off within a specified time after the outer bulb is broken; the other would be accompanied by a warning that it should be used only in areas where human exposure is unlikely to occur or in fixtures that provide protection against ultraviolet radiation.

Proposed Standard for Sunlamps

FDA has proposed a safety performance standard for sunlamps to reduce the possibility of injuries resulting from overexposure to sunlamp radiation. The proposal was published in the December 30 *Federal Register.*

Sunlamps are widely used in the United States, with about 1,000,000 being sold each year. Based on Consumer Product Safety Commissin data, some 10,000 sunlamp injuries requiring emergency room treatment were reported in 1974, and that number increased to 12,000 in 1975. Many of the injuries, such as severe sunburn and eye irritation, resulted from acute overexposure to ultraviolet radiation when users fell asleep under sunlamps that did not shut off automatically. The standard is being issued in an effort to reduce the number of such injuries.

The proposed standard would: (1) require that each sunlamp have a timer that shuts off the lamp within 10 minutes or less; (2) prohibit sunlamps from emitting excessive amounts of shorter wavelength radiation, which is particularly hazardous and not necessary for skin tanning; (3) require that sunlamps be sold with protective eyewear; (4) require warning labels and instructions stating that ultraviolet radiation, as with natural sunlight, may cause premature skin aging and skin cancer and recommending that people taking medication or with light-sensitive skin consult a physician before using a sunlamp; and (5) require that sunlamps be manufactured so they will fit only into special light fixtures equipped with appropriate timers, controls, and warning labels. It was proposed that the standard become effective 30 days after a final regulation is published. In the interim, FDA is urging manufacturers to take volunteer steps to prevent sunlamp injuries by equipping their products with such safety accessories as timers and protective eyewear and by providing purchasers with adequate instructions for safe use.

Education and Quality Assurance

Mercury Vapor Lamp Hazards

To alert the public to the potential health hazards associated with exposure to damaged mercury vapor and metal halide lamps, BRH sent warning notices to some 68,000 lighting designers, purchasers and users, environmental safety personnel, members of consumer groups, and Federal properties maintenance personnel. The notices explain that when the outer bulb is broken, intense ultraviolet radiation can escape and cause skin burns around the face and shoulders and severe eye irritation. They also list steps that can be taken to minimize the possibility of injuries.

d. High Voltage Transmission Lines

Private citizens, public interest groups, and State agencies have expressed concern about the potential adverse effects of electic power at extra-high voltages (EHV), i.e., voltages at or above 345 kilovolts. Because of these concerns, EPA published a notice in the *Federal Register* on July 31, 1975, requesting data and information on health and environmental effects of EHV power transmission. Over 50 replies totaling over 6000 pages were received, and in 1977 a contract was awarded to the Illinois Institute of Technology Research to extract and summarize the relevant comments. A draft had been prepared by the end of the year.

e. Lasers and Laser Products

Guidance

Variance for Laser Product

BRH granted the first variance from the Federal laser product performance standard, for a laser system designed for surveying applications. In applying for the variance, the manufacturer contended that, to be effective for its intended purpose, the system must emit light power in excess of the specified limits. BRH concluded that several safety features and additional precautions would suffice in providing radiation protection in accordance with Radiation Control Act regulations.

Department of Defense Studies

The Army conducted a number of studies using laboratory animals, phantom models or animal tissue, and will use the data generated to extrapolate human health effects of laser radiation. Specifically, the studies concern ocular and behavioral effects, and effects on skin and cutaneous tissue.

VII. OCCUPATIONAL EXPOSURE

1. Introduction and Summary

People who are exposed to radiation on the job add a certain amount to the dose received by the general public — whether they are physicians, x-ray technicians, nuclear power plant operators, uranium miners, or fire alarm makers. Because such workers are usually subject to higher doses than the general population, it is important to know how many are exposed to how much radiation, and what effects it has on them, if any. Data collected on occupationally exposed people can be useful in assessing potential effects on the general public.

An initial problem is defining who a radiation worker is. As the partial list below shows, sources of occupational exposure to ionizing radiation are by no means confined to medical and nuclear fuel cycle activities. Industrial exposures include not only obvious sources like thickness gauges and radiographic equipment, but also incidental sources like klystron tubes and radar tube testing operations.

Since there is so much room for dispute about who a radiation worker is, the number of workers exposed is uncertain. The Special Studies Group estimated in a 1972 EPA report that there were 772,000 such employees in 1969-70, "using reported numbers of workers [from the Atomic Energy Commission, other agencies, and medical and dental sources] and judicious estimates in nonreported ones [such as nonreporting Agreement States and AEC licensees]."[1] The total man-rem from occupational exposure was calculated at 164,000, with a mean annual dose of 210 mrem/worker.

Information about exposure is needed not only to insure compliance with applicable regulations but also to provide a data base for studies of health effects. Since cancer is the main known effect of ionizing radiation exposure, and since it may arise from any of many sources, continuing epidemiological studies of workers are especially informative.

According to EPA's Office of Radiation Programs' (EPA/ORP) May 1976 *Radiological Quality of the Environment*, "there is no requirement for uniformity in collecting and reporting occupational exposures. There are considerable variations in the terminology used by reporting agencies. For example, results of personnel monitoring data are reported as exposures (R), absorbed doses (rad) or dose equivalents (rem)."[2] The Federal Government maintains several registries which cover occupational exposure information, including DOE's voluntary Transuranium Registry and BRH's Radiation Incidents Registry as well as those maintained by the Armed Services and NRC.

Occupational exposure to nonionizing radiation is also surprisingly widespread. Lasers, for example, are used in the construction industry as reference lines — and in drilling, communications, holography, and surgery. (They are extremely hazardous to the worker's eye because of the intense concentration of light on the retina.) Microwaves, which are widely used in medical diathermy and other fields as well as in ovens, can affect eyes, and may have a health impact at low levels over a long period of time. For those who work out of doors, sunlight is a major source of ultraviolet light which may cause cancer, and certainly has irritating and damaging effects on the eye.

Federal responsibilities and selected activities related to radiation exposure are discussed below, categorized by agency. The information presented is far from exhaustive, but we hope that it will provide a sense of the diversity of occupational exposure and of the activities of Federal agencies which regulate it.

1. *Estimates of Ionizing Radiation Doses in the U.S.*, 1960-2000. EPA: ORP/CSD 72-1 (1972), page 147.

2. Radiological Quality of the Environment. EPA; EPA-520/1-76-010 (1976), page 151.

Summary

Activities in this chapter are arranged by agency, as follows:

EPA

— continued reviewing and updating the current Federal radiation protection guidance for occupational exposures to ionizing radiation.

— asked the National Academy of Sciences' BEIR Committee to consider the findings of the "Mancuso study" in its analysis of radiation risks under a current contract, in response to a Natural Resources Defense Council petition.

— continued a contract to review methods for obtaining reliable statistical data on annual occupational exposures to ionizing radiation in the United States.

NRC

— began research under contract to develop acceptable performance criteria for air-purifying respirators to protect against airborne radioiodines, and to measure the amount of protection they provide.

— provided medical institutions with guidance on their design and operation to protect workers.

— initiated development of a regulatory guide on acceptable health physics programs for uranium mills.

— completed a final environmental statement on personnel neutron dosimeters containing thorium.

— developed an action plan to reduce overexposures of industrial radiographers.

— issued for comment a revision of a Guide concerning occupational exposures at nuclear power stations.

— funded studies on exposure of airport workers and dosimetry models.

DOE

— conducted a range of studies to assess the possible effects of fusion power workers' occupational environment.

— completed the first phase of a multilaboratory intercomparison of *in vivo* plutonium lung counting.

— conducted workshops to define research needs in transuranic, tritium and neutron radiobiology.

— continued to collect data on human morbidity and mortality associated with occupational or accidental exposures.

MESA

— increased its radiation and other types of personal exposure monitoring.

— completed a special radiation exposure and recordkeeping audit which was launched in 1975, and as a result proposed more stringent sampling and recordkeeping standards.

OSHA

— continued to inspect workplaces for compliance with many standards, of which radiation is only one.

NIOSH

— completed a three volume report summarizing the current knowledge of radiation-induced carcinogenesis.

— provided technical assistance in addressing problems from radiation generating equipment.

— initiated an epidemiologic study of workers at the Portsmouth Naval Shipyard.

— studied current trends in survivorship of radiologists.

— updated an extensive bibliography on bioeffects of radiofrequency and microwave radiation, and conducted relevant studies.

— continued a wide variety of assessments of possible hazards and standards.

2. Environmental Protection Agency

Guidance

EPA/ORP continued its work on reviewing and updating the current Federal radiation protection guidance for occupational exposures to ionizing radiation. The current guidance used by agencies in preparing standards and regulations for their respective areas of authority was established by the Federal Radiation Council in 1960. The Interagency Committee on Occupational Exposures to Ionizing Radiation, formed by EPA/ORP in 1974, is consulted by EPA in reviewing and updating this guidance. It is anticipated that the proposed new guidance will be published in the *Federal Register* in 1978 for public comment.

The guidance will reflect current knowledge on the relationship between radiation dose and effects on health, existing and foreseen national needs for occupational radiation exposure, and recent recommendations by the National Academy of Sciences, International Commission on Radiation Protection, and National Council on Radiation Protection and Measurements. Radiation protection guidance will eventually be specified for individuals in a variety of occupational categories, through (1) a set of annual Radiation Protection Guides (RPG's) for irradiation of the whole body and individual organs or tissues, (2) qualitative guidance which specifies proper application of the RPG's, and (3) secondary guidance which provides practical means for implementation.

The technical support document for the new recommended guidance will address the somatic and genetic risks associated with the recommended limitations, the rationale for the guide values chosen, the "as low as is reasonably achievable" principle, the influence of prior exposures on an individual's radiation protection status, and guidance for special categories of workers such as occupationally exposed pregnant women and women of reproductive capacity, minors, students and trainees, itinerant and transient workers, as well as for visitors.

The appropriateness of the current age-related accumulated dose rule is also being reviewed. Under it, the accumulated dose (whole-body) of radiation workers is not to exceed 5 (N–18) rems where N is the person's age in years. Current guidance also limits the whole-body dose to three rems per quarter; thus, a radiation worker could receive up to 12 rems in a single year if his or her "dose account" under the 5 (N–18) rule permitted it. The rule is being examined to determine whether it should be retained.

Petition to Reduce Occupational Exposure Limits

The Natural Resources Defense Council, a nonprofit public interest group, petitioned EPA and NRC to reduce occupational exposure limits by a factor of 10 because of findings of the "Mancuso study." This study of death certificates for former radiation workers has caused considerable controversy in the scientific community, because preliminary results show an apparent increased cancer mortality in workers exposed at the Hanford nuclear facility. If valid, the results would indicate that current estimates of the risks due to chronic radiation are too small.

It is difficult to compare these results with other studies of radiation risks to humans, since this is the only study involving thousands of normally healthy people chronically exposed to low doses. The study, which now includes about 4,000 certified deaths, was started by the Atomic Energy Commission, later ERDA and now DOE. Performed until recently on contract by Dr. T.F. Mancuso, a respected professor at the University of Pittsburgh, its purpose is a long-term epidemiological review of radiation workers in selected major facilities. The focus has been on workers exposed since 1943 at the Hanford nuclear facility.

In response to concerns raised by the Mancuso study and the NRDC petition, EPA/ORP has asked the National Academy of Sciences' BEIR Committee to consider the study in its analysis of radiation risks under a current contract. It should be noted that the study is presented by its authors as a preliminary report, and it is too soon to make good judgments about what the final results will yield. A number of epidemiological centers are examining the data, and EPA/ORP will take their evaluations into account in making a final decision on the NRDC petition.

Studies

Annual Occupational Exposure Statistics

In 1975, EPA/ORP initiated a contract to review methods for obtaining reliable statistical data on annual occupational exposures to ionizing radiation in the United States. The Agency is considering establishing a program for routinely compiling national statistics on annual occupational exposures. The data collected would serve as the continuing surveillance of national occupational exposure trends, and would also be used to review and update Federal occupational radiation protection guidance. The present contract, slated for completion in mid-1978, is designed to provide:

— a thorough investigation and evaluation of actual and potential sources of input data,

— determination of the availability of the types of data considered necessary,

— development (on the basis of findings) of a set of effective and economical alternative means for carrying out the program, and estimating their annual cost and manpower requirements, and

— testing of the alternative means selected by EPA.

3. Nuclear Regulatory Commission

The NRC requires that external and internal radiation doses to persons employed in occupations involving potential exposure to radiation shall be controlled within strict limits. The NRC standards define the permissible occupational dose in rems-per-calendar-quarter (a rem is a measure of the biological effect of ionizing radiation, being equivalent to the effect of one roentgen of x-radiation). These allowable limits are set forth in 10 CFR Part 20.

The NRC collects, on a calendar year basis, occupational radiation exposure information from the four categories of licensees considered to have the greatest potential for significant personnel exposures: operating nuclear power reactor licensees, industrial radiographers, fuel fabricators and processors, and commercial processors and distributors of specified quantities of byproduct materials.

The annual reports collected from these 450 licensees disclosed that some 92,800 individuals were monitored during 1976 and that nearly half of these persons received exposures that were too small to be detected by personnel radiation monitoring devices. Only three exposures exceeded the maximum annual limit of 12 rems established by Federal regulations. The cumulative exposures received by all 92,800 individuals was 33,000 "man-rems"—an average exposure of 0.36 rem per person. This is the same average exposure as reported for 1975 (see 1976 NRC Annual Report, page 108). Most of these exposures occurred at the 62 nuclear power plants operating during 1976, where 66,800 persons accumulated a total of 26,555 man-rems (see NUREG-0322).

Exposure information is also collected from these licensees by way of employee termination reports submitted to the NRC whenever

Table 7.1

DISTRIBUTION OF ANNUAL WHOLE BODY EXPOSURES BY LICENSEE CATEGORY
1976

Covered Categories of NRC Licensees	Total No. Monitored	Less Than Measurable	Exposure Ranges (Rems)																
			Measurable < 0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12
POWER REACTORS																			
No. of Indiv.	66,800	30,085	13,859	5,277	4,192	2,537	2,036	4,882	2,355	789	487	188	70	26	11	5	1	0	0
Percent of Total	100%	45%	21%	8%	6%	4%	3%	7%	4%	1%	1%								
INDUSTRIAL RADIOGRAPHY																			
No. of Indiv.	11,245	5,023	2,184	1,208	887	544	353	660	210	100	41	15	10	3	2	0	2	0	3
Percent of Total	100%	45%	19%	11%	8%	5%	3%	6%	2%	1%									
FUEL PROCESSING & FABRICATION																			
No. of Indiv.	11,227	5,942	2,815	959	580	307	221	237	77	47	25	17	0	0	0	0	0	0	0
Percent of Total	100%	53%	25%	9%	5%	3%	2%	2%	1%										
MANUFACTURING & DISTRIBUTION																			
No. of Indiv.	3,501	1,525	906	413	170	94	53	148	77	51	31	16	10	5	2	0	0	0	0
Percent of Total	100%	44%	26%	12%	5%	3%	2%	4%	2%	1%	1%								
TOTALS																			
Number	92,773	42,575	19,764	7,857	5,829	3,482	2,663	5,927	2,719	987	584	236	90	34	15	5	3	0	3
Percent	100%	46%	21%	8%	6%	4%	3%	6%	3%	1%	1%								

an individual completes his employment or work assignment with one of them. These reports revealed that more than 32,000 persons terminated employment with these four categories of licensed facilities during 1976, and that 14,200 of these workers did so more than once. A continuing increase in these figures, at a rate of more than 20 percent each year, indicates a trend toward a greater use of short-term workers in nuclear power plant maintenance.

Guidance

Respiratory Protection

The NRC's rule change that included new requirements governing the use of respiratory protective equipment (respirators) to protect workers against airborne radioactive materials was published in November 1976 and became effective in December 1976. Licensees had until December 1977 to achieve full compliance with the new requirements. Guide 8.15, on acceptable practices for respiratory protection, and an associated manual on respiratory protection (NUREG-0041) were issued in October 1976.

Research work was begun under contract with Los Alamos Scientific Laboratory (LASL) to develop acceptable performance criteria for air-purifying respirators to protect against airborne radioiodines.

LASL also provided measurements of the amount of protection provided by respirators. This information will be used for revising and updating guidance to licensees on the amount of allowance that may be made for the protection that is provided when respirators are used to limit the internal radiation doses to workers who are exposed to airborne radioactive materials. All approved airline respirators were scheduled for testing this year. A revised informal report (LA-NUREG-6612 MS) with recommendations on the protection afforded by air-supplied hoods and helmets was completed in July 1977. The information will be used in providing additional and updated guidance to licensees on the acceptable use of these respirators.

Medical Institutions

Regulatory Guide 8.18 and an accompanying report (NUREG-0267) were issued in December 1977 to provide medical institutions with guidance on actions that should be taken in the design and operation of medical facilities to ensure that workers are adequately protected from the harmful effects of ionizing radiation.

Health Protection at Uranium Mills

Progress was made in evaluating the hazards associated with the inhalation of uranium ore dust by uranium mill workers. The principal hazard arises from thorium-230, a decay product of natural uranium, which is retained in the lungs and lymph nodes for long periods of time. Measurements made to date, however, indicate that many airborne particles of uranium ore dust are too large to be deposited in the lungs, so that thorium-230 may be less of a problem than had been supposed.

A regulatory guide on acceptable health physics programs for uranium mills is being developed. It will set forth the NRC staff position regarding health physics measurements that should be performed at mills and will take into account the importance of the chemical toxicity to the kidney of "yellowcake," the final product of a mill. The guide will draw heavily on preliminary measurements from studies of the inhalation of uranium-ore dust.

Dosimeters

To provide the regulatory environment for widespread use of personnel neutron dosimeters containing thorium, the NRC exempted the dosimeters from licensing requirements in February 1977. The final environmental statement (NUREG-0137) prepared in connection with the exemption was the first one issued for a consumer product. The statement concluded that, in order to protect the environment, manufacture of the dosimeters can take

Table 7.2

SUMMARY OF ANNUAL WHOLE BODY EXPOSURES FOR COVERED LICENSEES

1968-1976

Year	Total Number Monitored	Percent of Exposures < 2 Rems	Percent of Exposures >5 Rems	Number of Annual Exposures >12 Rems
1968	36,836	97.2%	0.5%	3
1969	31,176	96.5%	0.5%	7
1970	36,164	96.1%	0.6%	0
1971	36,311	95.3%	0.7%	1
1972	44,690	95.7%	0.5%	8
1973	67,862	95.0%	0.5%	1
1974	85,097	96.4%	0.3%	1
1975	78,713	94.8%	0.5%	1
1976	92,773	95.0%	0.4%	3

Table 7.3

LENGTH OF EMPLOYMENT FOR INDIVIDUALS TERMINATING EACH YEAR

	Calendar Year	1-89 Days	90-180 Days	180-365 Days	1-2 Years	2-4 Years	4-6 Years	>6 Years
Total Number	1976	1669	699	682	1015	970	358	1507
Total Cum. Dose Equivalent (Rem)		253.25	57.77	113.60	597.02	761.94	372.09	3972.86
Avg. Cum. Dose Equivalent (Rem)		.15	.08	.17	.59	.79	1.04	2.64

place only when authorized by a license issued by the NRC or an Agreement State, and each dosimeter must contain no more than 50 milligrams of thorium.

Overexposures of Radiographers

Overexposures of industrial radiographers to radiation have continued to be of concern to NRC. During fiscal year 1977 the staff developed an action plan to reduce such overexposures. The plan would improve safety in radiography through licensing and standards measures that would require improvement of radiography instruments, better training for radiographers, and adequate detection and alarm systems to warn them of radiation exposure.

Exposures at Nuclear Power Stations

In March 1977, the NRC issued for comment a revision of Guide 8.8. It provides considerably more detailed guidance on planning, designing, constructing and operating a light-water reactor nuclear power station to meet the objective that exposures of station personnel to radiation during routine operation must be as low as is reasonably achievable.

Studies

Airport Workers

The NRC issued in March 1977 a report, "Exposure of Airport Workers to Radiation from Shipments of Radioactive Materials" (NUREG-0154), reviewing studies conducted at six major U.S. airports. These studies showed that most of the monitored cargo workers receive annual radiation doses of less than 0.1 rem from handling such shipments. (A dose of 0.1 rem is equal to the average amount of radiation that a person would receive in one year from natural background sources.)

They also indicated that some of the exposures received by the cargo workers were attributable to unnecessary contact with the packages of radioactive material. Manuals and posters to instruct cargo workers on ways to avoid these unnecessary contacts were prepared during fiscal year 1977 and will be issued jointly by NRC and DOT in 1978.

Dosimetry Models

During FY 1977, a project was initated to improve the data base for predicting adverse health effects which might result from exposure to radioactive materials in a serious accident. Results achieved in fiscal year 1977 contributed to improvements in the dosimetry models—published in 10 CFR Part 50, Appendix I—for keeping exposure to levels as low as reasonably achievable. In addition, measurements were made at four operating nuclear power stations where new construction is under way as part of an effort to determine the sources and levels of radiation to which site construction workers might be exposed. New measurements also are being made of ambient levels of radium and uranium particulates present in uranium mills in order to better assess the occupational exposure at those facilities.

4. Department of Energy

DOE conducted a range of studies to assess the possible effects of fusion power workers' occupational environment. Research on the mutagenic and carcinogenic risk from neutrons resulting from nuclear fission applies to fusion technology, and to other studies on radiation effects. In the environmental field, studies were continued on the determination of tritium concentrations in the atmosphere and the oceans, the transport of tritium in rivers, estuaries and the Atlantic Ocean, and movement of tritium in soils and biota. Global inventories of tritium and tritiated water were updated. Relevant physical and technological research included a review of the health physics aspects of fusion power and a study of the chemical interactions of tritiated molecules.

As part of its programs, DOE completed the first phase of a multilaboratory intercomparison of *in vivo* plutonium lung counting. This technique is used to measure the amount of plutonium inhaled and retained by radiation workers. Also completed were development and initial testing of systems to monitor alpha aerosols in effluent streams, working areas and the external environment. Aerosols were characterized in working areas of nuclear facilities and uranium mines. To assist other groups, specific internal dose calculations were provided to standard setting bodies and regulatory agencies.

In 1977, DOE conducted workshops with leading scientists to define research needs in transuranic, tritium and neutron radiobiology. It was found that research is required on potential health effects of plutonium, high specific activity uranium and other transuranic radionuclides for several fuel cycles. Studies are being conducted with rodents and dogs, and are primarily concerned with dose-response relationships for lung and bone tumors in life span studies. The information developed in experimental animals for the assessment of the effects of low levels of external radiation can be correlated to some degree with the evidence of human exposure to determine risk for workers and for the general population. Relatively large numbers of animals must be exposed to low levels of gamma and neutron radiation over long periods of time. Specific activities include an evaluation of the hazards of iodine-129 in weanling rats and beagles, showing that each tenfold increase iodine intake means a threefold decrease in thyroid uptake.

In keeping with its plan to collect data on human morbidity and mortality associated with occupational or accidental exposure to radiation, DOE proceeded in 1977 with several

Table 7.4

WHOLE-BODY EXPOSURE HISTORY OF AEC/ERDA AND AEC/ERDA CONTRACTOR EMPLOYEES

(Percent of employees with dose equivalent greater than)

Year	1 rem (Number)	2 rem (Number)	Total Man rem*	Total Monitored
1964	4.85 (6254)	2.07 (2671)	13411	128965
1965	5.07 (6854)	1.99 (2696)	14818	135214
1966	4.65 (6410)	1.96 (2704)	14173	137932
1967	6.11 (6622)	2.23 (2415)	13715	108386
1968	4.43 (4780)	1.83 (1981)	9877	107986
1969	4.17 (4293)	1.69 (1739)	8707	102918
1970	4.63 (4476)	1.84 (1778)	9137	96661
1971	3.90 (3675)	1.37 (1295)	5395	94315
1972	3.78 (3383)	1.40 (1253)	6170	89460
1973	3.16 (2906)	1.05 (962)	5623	91977
1974	3.26 (2548)	1.13 (881)	4935	78232
1975	3.36 (2974)	1.28 (1128)	5813	88425
1976	2.47 (2231)	0.60 (552)	3984	90200

*This table reflects the trend in high exposures since individuals with dose equivalents of less than 1 rem have been excluded. The total cumulative dose equivalent has been estimated by using the midpoint of each dose equivalent range shown in Table 1.

studies which are to continue for some years. More people exposed to plutonium at six DOE facilities were identified, along with others who may serve as controls. To help confirm estimates of body burden, urine samples were collected and analyzed for plutonium content. Records were abstracted for use in mortality and morbidity studies, and DOE examined the feasibility of studying genetic effects of plutonium exposure. The Transuranium Registry continued as a means of following workers exposed to transuranium elements, with increased voluntary participation by DOE contractors and NRC licensees. Improved methods were developed for handling and preparation of autopsy tissues.

The Center for Human Radiobiology at Argonne National Laboratory continued to record and analyze biomedical data on humans who have acquired internally deposited radionuclides. Specifically, a report was completed on mortality among early radium watch-dial workers, including consideration of the amount of radium ingested; preliminary analyses of the fertility of female workers were finished. In addition, a study of morbidity and mortality among 4.500 former thorium workers continues. Mortality among male workers was compared to male U.S. death rates, and medical examinations and thorium burden estimates were obtained on about 50 long term male workers. Health questionnaires are also being collected.

5. Mining Enforcement and Safety Administration (MESA)

MESA generally increased its radiation and other types of personal exposure monitoring efforts during 1977, in terms of number of samples, inspections, and mines inspected. Inspectors collected 1,857 radon daughter samples during 219 inspections at 153 uranium mines (comparable 1976 figures were 1,180 samples, 191 inspections and 142 mines), and 915 radiation samples during 188 inspections at 163 nonuranium mines (comparable 1976 figures were 1,071 samples, 187 inspections and 154 mines). Table 7.5 summarizes Federal radiation sampling results in 1977. Average concentrations of radon daughters have steadily decreased in both uranium and nonuranium mines. The uranium mine average decreased from 0.71 WL (Working Levels) in 1975 to 0.58 WL in 1976 to 0.51 WL in 1977; the nonuranium mine average decreased from 0.31 WL in 1975 to 0.22 WL in 1976 to 0.12 WL in 1977.

Table 7.5 also provides a summary of radiation exposure data compiled from uranium mining company records. These records show that, like MESA sampling results, the average uranium miner exposure has steadily decreased—from 1.07 WLM (Working Level Months) in 1975 to 0.99 WLM in 1976 to 0.91 WLM in 1977. However, there continued to be an apparent discrepancy between Federal inspection results and company records. Projections from Federal samples indicated an average exposure of 5.68 WLM in 1975, 4.64 WLM in 1976, and 4.08 WLM in 1977.

Because of these apparent discrepancies, a special radiation exposure and recordkeeping audit was begun in 1975, continued in 1976, and completed in 1977. Twenty underground uranium mines employing 1,604 miners were visted by MESA auditing teams. Table 7.5 shows the results of the audit, which confirmed that uranium miner exposure was significantly greater than indicated by operators' records. In fact, the audit data led to exactly the same projection as did the 1976 Federal inspection data—an average exposure of 4.64 WLM based on an average concentration of 0.58 WL.

In light of the compelling evidence that operators' procedures for estimating miner radiation exposure were inadequate, more stringent sampling and recordkeeping standards were proposed by all interested parties during public hearings held in the summer of 1977, and a favorable recommendation by the Administrative Law Judge was imminent at the end of the year.

Table 7.5

RADON DAUGHTER CONCENTRATIONS, 1977

Type of mine	Total number of samples	Average concentrations	Maximum concentrations	Number of samples in designated range				
				0.0-0.3 WL	0.3-0.6 WL	0.6-1.0 WL	1.0-2.0 WL	>2.0 WL
Uranium mines	1,857	0.51 WL	20.90 WL	1,037	396	221	112	91
Nonuranium mines	915	0.12 WL	6.20 WL	787	91	32	2	3

1977 URANIUM MINE EXPOSURE

Total employment	Average exposure	Miners having exposure in indicated intervals, percent				
		0.1 WLM	1-2 WLM	2-3 WLM	3-4 WLM	>4 WLM
5,315	.91 WLM	61.8	21.7	12.4	3.8	0.2

RADIATION RECORDKEEPING AUDIT, 1976-77

Total number of samples	Average concentrations	Maximum concentrations	Number and percent of samples in designated range				
			0.0-0.3 WL	0.3-0.6 WL	0.6-1.0 WL	1.0-2.0 WL	>2.0 WL
1,882	0.58 WL	24.0 WL	653 34.7%	473 25.1%	329 17.5%	291 15.5%	136 7.2%

6. Occupational Safety and Health Administration

Simply put, the Department of Labor's Occupational Safety and Health Administration (OSHA) has jurisdiction over workers who are exposed to radiation but not covered by other agencies. OSHA inspects workplaces (where there is even one employee) for compliance with dozens of standards—of which radiation is only one. Therefore, there are no definite figures on the number of workplaces or workers that OSHA is responsible for, in terms of radiation protection alone.

The breadth of situations involved is enormous, from electron microscope workers to pipefitters. Although the Occupational Safety and Health Act covers Federal contractors as a matter of form, in practice the agencies contracting with them are responsible for enforcement. Federal employees, while not covered under the Act, are to be protected by a comparable agency plan.

7. National Institute for Occupational Safety and Health

NIOSH has several vital functions related to protecting workers from workplace hazards, including ionizing and nonionizing radiation. These include the conduct of research programs, the performance of hazard evaluations, field studies, morbidity and mortality studies, the development of recommended standards, and the provision of technical assistance.

The development of criteria documents as a basis for standards for the occupational exposure to chemical and physical hazards is a continuing activity of NIOSH. These criteria documents are prepared for the purpose of recommending occupational health and safety standards to the Occupational Safety and Health Administration (OSHA) and recommending health standards for mines to the Mine Safety and Health Administration (MSHA). Both of these agencies within the Department of Labor are responsible for setting and enforcing standards to protect workers. It is the goal of the Institute to identify the health effects produced by a substance or process and to recommend methods to evaluate and control the hazard. Before the documents are transmitted they undergo extensive internal and external review by management and trade associations, organized labor, academia, State and Federal agencies, and professional societies.

One of NIOSH's major efforts mandated by Congress is the study of industrial carcinogens. NIOSH has completed a three volume report summarizing the current knowledge of radiation-induced carcinogenesis. The information will assist Federal and State agencies in estimating the potential carcinogenicity of the various types of ionizing and nonionizing radiation and will help to update the National Academy of Sciences 1972 BEIR Report.

For the past decade, NIOSH and its predecessor organizations have been gathering, analyzing, and publishing epidemiologic data on the hazards to workers from radon daughter products present in the uranium mining and milling operations. At this time a cohort of miners exposed to low concentrations of radon daughters is still being followed to identify if there is an excess lung cancer risk in this specific group.

NIOSH has provided technical assistance in addressing problems from radiation-generating equipment. For example, because of employee concern for the possibility of excessive ionizing radiation exposure, the Federal Aviation Administration (FAA) and the Air Transport Association (ATA) requested NIOSH to evaluate the potential radiation hazards to airport personnel working with baggage X-ray inspection units. NIOSH concluded that the doses received by airport personnel were well below the OSHA exposure standard and that the radiation hazard was minimal.

NIOSH is initiating an epidemiologic study of workers on nuclear propulsion ships and other workers at the Portsmouth Naval Shipyard. The study will attempt to evaluate the workers' exposure to low-level radiation and to other possible health hazards to determine whether there is increased incidence of cancer among the workers, and if this is associated with radiation or other exposures. If appropriate, the study may be expanded to other shipyards involved with nuclear propulsion ships.

Work proceeded on a NIOSH funded Johns Hopkins University study of current trends in survivorship of radiologists, designed to determine whether they are still subject to a greater risk of cancer than other doctors, despite the decreased dose of radiation to which they have been exposed in recent years. In addition the research will try to identify dose levels of radiation and other toxic agents to which various medical specialty groups are exposed, and to relate these data to cause-specific mortality.

In the nonionizing area, NIOSH updated an extensive bibliography of world literature of the bioeffects of radiofrequency and microwave radiation. A retrospective epidemiologic study has been started to determine whether TACAN radar system repairmen exhibit an increased incidence of cancer of the pancreas and other carcinomas.

Under an interagency agreement with the National Bureau of Standards, RF detection equipment was developed to measure the electric and magnetic components in the near-field (10-300 MHz), which encompass NIOSH-studied worker exposure situations. NBS also developed a unique RF exposure and calibration facility, which has been used to evaluate commercial monitoring instrumentation which manufacturers claim to be usable from 10 to 300 MHz.

In a NIOSH field study, 75 percent of the sources used for RF sealing and heating were found to exceed the present American National Standards Institute (ANSI) occupational exposure standard for RF radiation. A majority of the workers around this equipment were women of child-bearing age. Because recent literature indicates that exposure of pregnant animals to RF radiation may harm the fetus, animal studies were begun to determine threshold levels for teratogenic effects from RF exposure.

To deal with the possible ultraviolet (UV) hazard, portable monitors were developed and underwent initial testing and evaluation. NBS cooperated with NIOSH in developing a UV transfer standard and in establishing an appropriate calibration facility. To determine whether the recommended standard for UV radiation should be updated, a review was undertaken of recently published bioeffects data.

Other data being developed to support an exposure standard are the result of ongoing animal studies to assess the eye damage resulting from near-infrared radiation. NIOSH staff assisted the World Health Organization in writing an infrared radiation occupational guideline.

Additional NIOSH projects involve an integrated approach to evaluating optical radiation hazards, including ultraviolet, visible, and infrared spectral regions. For example, an examination of the hazards of the welding process was completed in conjunction with the American Welding Society, and surveys of radiation emissions from equipment in newspaper composition rooms were conducted at the request of the Newspaper Guild. Assistance in evaluating optical hazards is provided by a calibration and testing facility with several standard sources and detectors for the calibration of laboratory and field instruments. A quality assurance program is also being conducted to perform long term studies on the stability, accuracy, and reproducibility of the instruments. It should also be noted that NIOSH is evaluating industrial hygiene monitoring instruments and personal protective equipment, including welder's filter plates, that will protect workers from optical radiation exposure.

As part of its responsibilities for personnel development, NIOSH presents short-term training courses in occupational safety and health; two of the specialty courses address the problems associated with ionizing and nonionizing radiations.

VIII. COMPREHENSIVE EXECUTIVE ACTIVITIES

This Chapter covers activities which cross the boundaries established in the others, such as regulations on ocean dumping of many kinds of radioactive waste, and research on low level radiation effects.

Guidance

Transuranium Contamination

Under its authority to provide guidance to Federal agencies, EPA proposed limits on the dose that individuals may receive from transuranium elements present in the environment as a result of existing or possible future unplanned contamination. The proposed guidance was published in the November 30, 1977, *Federal Register* (42 F.R. 60956). A 90 day public comment period was provided, to end February 28, 1978. The guidance is based on an integrated approach, using models incorporating current information on environmental transport mechanisms, human uptake and dosimetry, and risk conversion factors.

When the guidance is finalized, it will be applicable to all Federal facilities and be advisory to the States.

The primary criteria used in deriving the proposed guidance were that any added risk to an individual from exposure to the transuranium elements be very small, and that any actions required by implementation of the guidance be practical in terms of overall economic requirements. The risk at the proposed guidance level is estimated to be less than one chance in a million per year, and less than ten chances per hundred thousand in a lifetime, that an individual would develop a cancer from continuous exposure at the stated dose rates. In practice, very few, if any, individuals are expected to be subjected to the recommended guidance limits, and the total number of individuals exposed above levels of worldwide fallout will be small.

Specifically, the proposed guidance states that:

1. The annual alpha radiation dose rate to members of the critical segment of the exposed population as the result of exposure to transuranium elements in the general environment should not exceed either:

a. 1 millirad per year to the pulmonary lung, or

b. 3 millirad per year to the bone.

2. For newly contaminated areas, control measures should be taken to minimize both residual levels and radiation exposures of the general public. The control measures are expected to result in levels well below those specified in paragraph one. Compliance with the guidance recommendations should be achieved within a reasonable period of time.

3. The recommendations are to be used only for guidance on possible remedial actions for the protection of the public health in instances of presently existing contamination or of possible future unplanned releases of transuranium elements. They are not to be used by Federal agencies as limits for planned releases of transuranium elements into the general environment.

EPA/ORP's Standards for the Uranium Fuel Cycle

As detailed in last year's report, EPA/ORP published new final radiation protection standards for planned releases from the uranium fuel cycle on January 13, 1977 (42 F.R. 2858). NRC began developing implementation plans, since it is responsible for carrying out the standards. As part of its normal licensing process, NRC issues detailed technical specifications and regulations for radioactive effluents from each of the specific facilities involved in the fuel cycle. In this connection, EPA/ORP has concluded that the guidance issued in 1976 by NRC for control of effluents from individual light-water-cooled reactors will provide appropriate implementation of the standards at most existing reactor sites.

Passage of the Clean Air Act Amendments raised questions about how the new requirements of that Act will be integrated into the EPA standard, and NRC and EPA/ORP are jointly working to resolve the issue.

Ocean Dumping

EPA/ORP continued development in 1977 under PL 92-532, the Marine Protection, Research and Sanctuaries Act of 1972, of packaging requirements, site selection criteria, and monitoring requirements for the ocean disposal of low-level radioactive wastes.

From August 28 through September 2, 1977, EPA/ORP conducted the first phase of a comprehensive Farallon Islands radioactive waste disposal site survey at 900m and 1700m depths. The ship used for this operations phase was the Velero IV. Scientists on board were specialists in the fields of marine zoology, radiochemistry and geology.

The major objectives were met:

(1) to obtain undisturbed sediment cores at selected positions within and outside the site area; to analyze them for the presence of radionuclides, with emphasis on cesium and plutonium, and for the biological populations within the sediments, as well as the chemical-geological properties which determine the distribution of released radioactive materials on the ocean bottom;

(2) to conduct trawls at bottom and mid-water depths, to characterize thoroughly the site area's biological populations and to radioanalyze selected samples;

(3) to obtain large-volume water samples, to be analyzed for salinity, temperature, and the presence of radionuclides;

(4) to map bottom depths throughout the site area;

(5) to document these oceanographic operations photographically.

Between October 10 and October 20, 1977, the second phase of the comprehensive survey was implemented. The objectives of drum recovery and current meter emplacement were met, using the Velero IV, the submersible PISCES VI and mother ship Pandora.

Following the 1976 EPA recovery of a low-level radioactive waste container in the Atlantic, the same program task was performed at the 900m Farallon Islands radioactive waste disposal site. The container was recovered in order to determine long-term corrosion processes in the deep ocean. EPA's Ocean Dumping Regulations, issued January 11, 1977, require that low-level radioactive wastes be contained and isolated from the marine environment to prevent their direct dispersion or dilution in ocean waters. Also, the containerized wastes must radiodecay to innocuous materials within the life expectancy of the container and/or its inert matrix. Yet to be studied is the effect of specifically identified environmental conditions on the reduction or acceleration of the corrosion process.

In addition to drum recovery, the following tasks were successfully performed:

(1) emplace current measurement systems in and around the dumpsite to look at the current vectors and subsequently the radionuclide transport potential;

(2) obtain precisely positioned sediment cores around waste containers, to be analyzed for radionuclides present;

(3) obtain selected biological samples, and study bottom topographic features and physical evidence of sediment transport;

(4) to document the operations photographically.

The drum, and all sediments, biological and water samples collected during the two phases of EPA's 1977 radioactive waste disposal site survey are being analyzed in contractor laboratories. At-sea scientific and technical support for the program came from government, university, and private sectors.

Effluents with International Implications

EPA/ORP chaired an the Expert Group of the Committee on Radiation Protection of the Nuclear Energy Agency, which is part of the international Organization for Economic Cooperation and Development. The Group's purpose is to develop recommendations on control of radioactive effluents with international implications. In 1977, the Group selected four nuclides for study: tritium, carbon-14, krypton-85, and iodine-129; their recommendations will be based on an examination of all aspects of the management of the radionuclides, from production through waste disposal. The results are expected to be especially important because the membership of the Nuclear Energy Agency includes all nations which are significant national users of nuclear power. Complete environmental dose commitments and control costs are among the factors being calculated, and they should be completed in 1978.

Radioactivity in the Great Lakes

As provided in the 1972 U.S.-Canadian Agreement on the Great Lakes, EPA forwarded to the State Department the "Refined Radioactivity Objective for the Great Lakes." It has undergone interagency review, and the State Department has accepted it as a basis for further negotiations with Canada.

The Refined Objective represents the joint recommendations of U.S. and Canadian advisory groups on preserving the water quality of the Great Lakes. The recommended level of radioactivity is that which results in a whole-body dose equivalent not exceeding one millirem. In addition, the release of the radioactive materials should be as low as reasonably achievable, and controlled by specified actions at defined levels.

EPA will assist in implementation of the Objective by analyzing both water and fish samples, with the major effort directed toward the ambient wastes of the Lakes and other areas not covered by the jurisdiction.

Interagency Cooperation

On August 2, 1977, the heads of the EPA, Consumer Product Safety Commission, Occupational Safety and Health Administration, and Food and Drug Administration issued a joint memorandum on interagency cooperation. They established working groups to look at the common requirements and functions involved in regulating hazards to public health and the environment. EPA/ORP has participated in the working group on radiation protection of the Interagency Liaison Regulations Group. It was agreed that the major emphasis would be in areas where two or more of the four agencies are involved and have major roles: medical exposure, nonionizing radiation, occupational exposure, and consumer products.

Review of Proposed Transportation Regulations

EPA/ORP commented on two sets of regulations proposed by the Department of Transportation (DOT) regarding transportation of radioactive materials. The first would have changed the method of radionuclide classification from treating each like the most restricted radionuclide in its class, to treating it on an individual basis. This change would make U.S. regulations consistent with International Atomic Energy Agency regulations, and pertains only to imported packages of radioactive materials. In its review of this DOT proposal, EPA/ORP objected that no comprehensive assessment had been made of the appropriate minimization of long-term impact on populations or individuals. Further, EPA recommended that in the future, new proposals for regulations should be accompanied by analyses of environmental dose commitments for normal and accident situations, and full consideration of the cost-effectiveness of available control alternatives for dose reduction.

In the second action, DOT proposed changes in requirements for carrying radioactive materials aboard commercial aircraft. EPA/ORP pointed out that they were inconsistent with current Federal radiation protection guidance in that the proposed levels were not, in EPA's view, as low as reasonably achievable; in fact, the exposure limit was four times EPA's recommendation of 0.5 mrem/hr at the passenger seat level. Another problem with the proposed regulations was that they depended on the placement of packages in the hold to maintain the dose limit, rather than on more effective shielding of packages.

Quality Assurance

Because EPA/ORP's dose assessment program relies heavily on surveillance data reported by other agencies and groups, the validity of the data must be confirmed. EPA/ORP therefore operates a Radiation Quality Assurance Program through its Environmental Monitoring and Support Laboratory in Las Vegas. The two major activities of the program are the distribution of calibrated radionuclide solutions, and laboratory intercomparisons for the analysis of radionuclides in environmental media. This program is available to all Federal, State, local, and private laboratories. More laboratories of NRC licensees or their contractors are now analyzing intercomparison samples from EPA's Quality Assurance program, as a result of the 1976 EPA-NRC Interagency Agreement for participation of such laboratories in the Program.

A significant addition, radium-228, has been made to the list of calibrated radionuclide solutions. Its availability is important in the analysis for naturally-occurring radioactive nuclides in various media, in particular for water analyses under the Safe Drinking Water Act. The calibrated radium-228 solution was prepared for EPA by the National Bureau of Standards.

Extensive laboratory intercomparison studies involving various environmental media containing a number of radionuclides were conducted to help environmental radiation laboratories improve their measurements. Radionuclide concentrations in these media were generally at or somewhat above current ambient radionuclide concentrations. The kinds of intercomparison analyses, their frequency, and the number of laboratories participating are presented in Table 8.1. Analysis of strontium-89/90 in water has also been added to the intercomparison list this year.

On-site evaluation of radioanalytical laboratories for certification under the Safe Drinking Water Act has begun. Most evaluations have been made by personnel of the Quality Assurance Branch, Las Vegas, at the request of Regional Administrators. The evaluations are primarily for drinking water analyses, but improvements in laboratory performance for all media can be expected.

Several reports were issued in 1977 describing activities of the Quality Assurance Program, including:

— *The Status and Quality of Radiation Measurements for Air.* EPA Environmental Monitoring and Support Laboratory, Office of Research and Development: EPA-600/4-77-043 (October 1977).

— *Status and Quality of Radiation Measurement: Food and Human Urine*, EPA Environmental Monitoring and Support Laboratory, Office of Research and Development: EPA-600/4-77-047 (October 1977).

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Table 8.1

ENVIRONMENTAL RADIOACTIVITY INTERCOMPARISON PROGRAM - 1977

Type of cross-check	Number per year	Laboratories participating
Gamma* in water	6	86
Tritium in water	6	95
Nuclides** in milk	6	68
Gross alpha and gross beta in water	6	85
Radium-226 in water	4	47
Nuclides*** on air filters	4	72
Nuclides in diet	4	28
Tritium in urine	4	19
Krypton-85 in air	3	19

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*^{60}Co, ^{106}Ru, ^{134}Cs, ^{51}Cr, ^{65}Zn

**^{89}Sr, ^{90}Sr, ^{131}I, ^{140}Ba, ^{137}Cs, and ^{40}K,

***Gross alpha, gross beta, ^{90}Sr, ^{137}Cs,

— *Quality Control for Environmental Measurement Using Gamma-Ray Spectrometry:* Interagency Energy Environment Research and Development Program Report, EPA Environmental Monitoring and Support Laboratory, Office of Research and Development: EPA-600/7-77-144 (December 1977).

— *Environmental Radioactivity Laboratory Intercomparison Studies Program FY 1977,* EPA Environmental Monitoring and Support Laboratory, Office of Research and Development: EPA-600/4-77-001 (January 1977).

— *Handbook for Analytical Quality Control in Radioanalytical Laboratories:* Interagency Energy Environment Research and Development Program Report, EPA Office of Research and Development: EPA-600/7-77-088 (August 1977).

Studies

EPA/ORP's Research Committee

The EPA/ORP Research Committee emphasizes needs related to emerging future issues rather than continuing or completing well established, ongoing projects. Following the process of identifying needs and deciding which are most important, the Committee acts as an advocate for pursuing them in agencies with appropriate research responsibilities.

Initially, EPA/ORP identifies particular radiation problems in four major areas: nuclear energy, naturally-occurring radionuclides, medical and industrial uses of radiation, and nonionizing radiation. Information needs are then determined with respect to health effects, ecological process and effects, measurement technique development, and operational study.

A few general areas identified in 1977 as needing further study are transuranic toxicology and pathways; nonionizing, radiation toxocology; emission, measurement and toxicity of radon and its daughters; age sensitivity to ionizing radiation; control of uranium mill tailings piles; and various issues relating to waste and uranium mining by new methods.

Dose Assessment Program

Since 1975, EPA/ORP has been conducting a nationwide dose assessment program to analyze trends, identify problems and provide support for establishing (and evaluating the implementation of) environmental radiation standards and guides. Major objectives of the program are to:

— determine the status of U.S. environmental radiation data,

— analyze the available data in terms of individual and population doses,

— develop guidance for improving the collection, interpretation and reporting of the data, and

— provide information to guide EPA/ORP.

The general approach of the program is to maximize the use of extensive effluent and environmental monitoring data reported by other State and Federal agencies, including DOE and NRC, and individual nuclear facilities. These data will be complemented as needed by data acquired from EPA/ORP's Environmental Radiation Ambient Monitoring System (ERAMS), radiation source-related field studies, and dose computational modeling. Only EPA/ORP gathers such a comprehensive data base for radiation dose assessment.

Radiological Quality of the Environment

As part of EPA's dose assessment program, the Office of Radiation Programs initiated an annual evaluation of the radiological quality of the environment. The first report, in 1976, summarized individual and population dose data for both ionizing and nonionizing radiation, with primary emphasis on identifying

Table 8.2

Summary of dose data from all sources, United States

Source	External		Internal	
	Individual dose (mrem/y)	Population dose (person-rem/y)	Individual dose (mrem/y)	Population dose (person-rem/y)
Ambient ionizing radiation	-	-	-	-
Cosmic radiation	41-45	9.7×10^6	-	-
Ionizing component	28-35	9.2×10^6	-	-
Neutron component	0.33-6.8	4.9×10^5	-	-
Worldwide radioactivity				
Tritium	-	-	0.04	9.2×10^3
Carbon-14	-	-	1	-
Krypton-85	[a].035*	-	-	-
Terrestrial radiation	30-95	-	18-25	-
Potassium-40	17	-	16	-
Tritium	-	-	4×10^{-3}	-
Carbon-14	-	-	1	-
Rubidium-87	-	-	0.6	-
Uranium-238 series	13	-	2-6*	-
Thorium-232 series	25	-	7*	
Technologically enhanced natural radiation	-	-	-	2.73×10^6
Ore mining and milling	-	-	100,000*	-
Inactive uranium mill tailings piles	-	-	[b]140-14000	[c]2.5-70000
Phosphate mining & processing (occupational)	10-300*	-	[b]6,000*	-
Fertilizer	1.7*	-	-	-
Thorium mining and milling	-	-	-	-
Radon in potable water supplies	-	-	[b]4,000([d]1,250)*	-
Radon in natural gas	-	-	[b]15-54	2.73×10^6
Radon in liquefied petroleum gas	-	-	1-4	30000
Radon in "health" mines	-	-	-	-
Radon daughter exposure in natural caves	-	-	-	-
Radon and geothermal energy production	-	-	-	-
Radioactivity in construction material	-	-	-	-
Airplane travel				
Jet (cosmic), per trip over Atlantic	2.6(500-crew)*	-	-	-
SST (cosmic), per trip over Atlantic	2.0(1,000-crew)*	-	-	-
Coal-fired electric generating station	-	-	5-70*	$0.12\text{-}2 \times 10^6$*
Oil-fired electric generating station	-	-	0.04*	15*

Summary of dose data from all sources, United States

Source	External Individual dose (mrem/y)	 Population dose (person-rem/y)	Internal Individual dose (mrem/y)	 Population dose (person-rem/y)
Fallout	[e]~ 2	-	-	-
Uranium fuel cycle	-	2014	-	-
Mining and milling	-	-	[f]4.5×10^{-2}	2.5
Fuel enrichment	[g]<0.1	<0.1	[h]0.3	[i]0.64
Fuel fabrication	-	-	[j]2×10^{-4}	[j]0.66
Power reactors BWR	[k]76 max	[m]1564	-	-
PWR	[k]4 max	[m]21	-	-
Research reactors	-	-	-	-
Transportation - Nuclear power industry	-	[n] 100-9600	-	-
Radioisotopes	-	[n]<170		-
Reprocessing and spent fuel storage	[p]6	[p]23	[p]14-257	-
Radioactive waste disposal	-	-	-	-
Federal Facilities	-	[q]480	-	-
ERDA	[k]<0.1-258	<1-180	-	-
Department of Defense	<0.01	-	-	-
Accelerators	[k]0.04-4	0.4-65	-	-
Radiopharmaceuticals	-	[r]<0.1	-	[s]3.3×10^{6}
Medical radiation				
X radiation	[t]103	14.8×10^{6}	-	-
Cardiac pacemakers	-	-	<5000	-
Occupational and industrial radiation				
BWR	[u]1230	-	-	-
PWR	[u]1080	-	-	-
All occupations	[v]0.80	28,400	-	-

Table 8.2 cont. Summary of dose data from all sources, United States

Source	External		Internal	
	Individual dose (mrem/y)	Population dose (person-rem/y)	Individual dose (mrem/y)	Population dose (person-rem/y)
Consumer products	-	-	-	-
Timepieces	[x]<0.5*	[y]~6100	-	-
Smoke detectors	[z]0.007*	0.001*	-	-
Artificial teeth	-	-	[aa]140-1390*	-
TV	[bb]0.025-0.043	-	-	-

	Individual exposure ($\mu W/cm^2$)
Nonionizing electromagnetic radiation	
Broadcast towers and airport radars	10
All sources	0.1-1

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[a] Maximum individual dose to skin surface

[b] Trachea-bronchial dose

[c] Lung-rem/y

[d] Stomach dose

[e] 50-year dose commitment divided by 50

[f] Average individual lung dose within 80 km

[g] Maximum potential exposure per facility

[h] Maximum potential exposure

[i] Cumulative exposure per facility within 80 km radius

[j] Estimated bone dose within 80 km

[k] Fence line boundary dose

[m] Within a radius of 80 km

[n] Estimated for the year 1973

[p] For NFS Reprocessing Plant, West Valley, N.Y.

[q] 1965 data

[r] Based upon data from 5 institutions

[s] Estimated 1980 dose

[t] Estimated mean active bone marrow dose to adults-mrad/y

[u] Average occupational exposure/y

[v] Average exposure for all occupations & 3.7 radiation workers/1000 persons in United States

[x] From digital watches

[y] From timepieces containing tritium or radium-activated dials

[z] Estimated

[aa] Dose to the superficial layer of tissue

[bb] 5 cm from TV set; units of mR/h

- No dose data available

*Indicates new or revised information

source categories of ionizing radiation (EPA-520/1-76-010). Sources in that category include ambient environment, technologically enhanced natural radiation, fallout, uranium fuel cycle, Federal facilities, medical, occupational, and others. The nonionizing radiation category is mainly concerned with environmental sources.

Literature searches have been conducted for each of those sources, with data organized to provide: general information about each source category and availability of data, data base description, status of data base analyses, summary of dose data for each source, comparison of reported dose data with estimates from previous publications, and discussion and conclusions.

Table 8.2 summarizes the individual and population doses in the United States from each category of radiation source discussed in the report. The information is divided according to the primary mode of exposure: external—which results in a radiation dose to the whole body, or internal—when radioactive materials are inhaled, ingested, or occasionally absorbed through the skin, often resulting in a radiation dose to particular organs of the body.

Population doses from the different source categories can generally be added together to gain a perspective on overall impact. However, doses to individuals vary greatly, so it can be misleading to total individual doses. For this reason, the data show totals only for population doses, not individual doses, in the various source categories.

Facility Data Analysis Project

One object of EPA/ORP's dose assessment program is improving the quality of surveillance data. For this purpose, a facility data analysis project was developed to evaluate the rationale for surveillance programs and to examine their components. Early phases of the project have dealt with criteria for summarizing and using ambient data, development of data analysis techniques, dose conversion criteria, and the development of a manual on sampling methodology.

Information from these initial phases will be used to evaluate surveillance programs at several commercial and Federal nuclear facilities. These reviews will aid in developing criteria for the evaluation of surveillance programs and later will lead to an updating of EPA/ORP's *Environmental Radiation Surveillance Guide* (ORD/SID 72-2).

Environmental Radiation Ambient Monitoring System (ERAMS)

ERAMS is an EPA/ORP program for continuing surveillance of radioactivity levels throughout the U.S. and its territories. Over 7,000 individual analyses are performed annually on samples of air, airborne particulates, deposition, surface and drinking water, and milk.

In 1978, ERAMS will be expanded to include measurements at the 21 continuously monitoring air sampling sites for ambient gamma radiation by means of thermoluminescent detectors.

After samples are collected by State and local health agencies, they are analyzed at EPA/ORP's Eastern Environmental Radiation Facility (EERF) at Montgomery, Alabama. The present ERAMS emphasis is towards identifying trends in the accumulation of long-lived radionuclides in the environment. Therefore, specific analyses are made for uranium-234, uranium-238, plutonium-239, carbon-14, tritium, strontium-90, and krypton-85. Measurements are also made for gross alpha and beta activity, and the gamma emitters iodine-131, cesium-137, barium-140, and potassium-40.

A quarterly summary of raw ERAMS data, which includes a limited amount of surveillance data from States, is reported in *Environmental Radiation Data* (available from EPA, Eastern Environmental Radiation Facility, P.O. Box 3009, Montgomery, AL 36109). These quarterlies consist mainly of data tabulations without interpretation or discussion, and are reviewed annually in EPA/ORP's report on the *Radiological Quality of the Environment*. An in-depth analysis of ERAMS is being carried out to determine annual averages, to identify trends, to characterize the statistical distributions of data sets, to estimate individual and population doses, and to evaluate error terms for each of these determinations.

Radioactive Air Emissions Studies

EPA/ORP began gathering information on characterizing the types, levels and effects of radioactive air emissions to determine whether they should be controlled. The studies are the outcome of EPA's being given major new responsibilities under the Clean Air Act as amended in August 1977. While the original Act did not include radioactive materials, the recent amendments expanded the Agency's mandate to cover all radioactive emissions including source, special nuclear, and byproduct material (defined in the Atomic Energy Act). Initially, EPA/ORP is responsible for studying the effects on public health of radioactive air pollutants which are or will be present in the ambient air. By August 1979, the Administrator must decide which emissions should be controlled, and follow a course of possible actions prescribed by the Amendments. The initial studies, begun in 1977, include previously unregulated natural sources; self regulated sources, such as Department of Energy and Department of Defense sources; and sources licensed by the Nuclear Regulatory Commission.

Polish/American Glacier Pollution Study

In July EPA/ORP supported a Polish/American glacier pollution study on Mt. McKinley, conducted by a team of five Polish expert alpinists and scientists, and one EPA/ORP and one U.S. Geological Survey scientist. The purpose of the Alaskan expedition was to collect glacier ice samples, which represent historical records of atmospheric depositions of naturally-occurring radionuclides and heavy metals. It was the last in a series of seven expeditions on four continents to assess the long distance effects of industrial operations.

The ice samples will be analyzed to determine the significance of build-up in the environment of long-lived radionuclides (uranium, thorium, and daughters) and stable elements (cadmium, mercury, vanadium, and lead). Contemporary and ancient people are being compared in terms of certain nuclides and stable elements present in samples of human bones and other tissues. The samples have been taken from Poland, the USSR, and Egypt.

Health Effects of Transuranics

To develop an accurate estimate of potential health effects due to plutonium in the environment, the Agency developed new assessments of the dose due to the inhalation and ingestion of transuranics. These dosimetric models differed from those previously used to establish Federal guidance in three ways. First, they provided information on the dose as a function of time from chronic exposure, so that the variation of the annual dose throughout a lifetime could be considered. They also took account of the increased dose due to daughter radionuclides in transuranic decay schemes, and were based on the new ICRP task group lung model rather than the 1959 ICRP dose models currently used in most Federal regulations.

Health effects due to plutonium and other transuranics were based on new studies of human groups exposed to alpha emitters. One new source of data was German patients treated with radium-224, a bone seeker similar to plutonium. Data from these patients provided a better estimate of the bone cancer risks due to transuranics than were previously available. The risk of liver cancer was

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Supplies were flown in for the four week Polish-American glacier polution study on Kahiltna Glacier, Mt. McKinley, Alaska.

Flags represent scientists and alpinists from Poland and the U.S. Environmental Protection Agency participating in a glacier pollution study on Mt. McKinley, Alaska.

estimated from clinical experience following the use of thorotrast in diagnostic radiography. (See Nelson, N.S., Ellett, W.H., Cook, J.R., and F.A. Hodge, "Estimated Risk of Liver Cancer Due to Alpha Emitters and Beta-Alpha Emitting Parent-Daughter Chains; an Application of Thorotrast Data," to be published, Environmental Research (1978).) Risk coefficients estimated from these data and the dosimetry information described above were used in a life table analysis that provides estimates of the hypothetical increased cancer risk to a cohort of 100,000 persons residing in a contaminated area at the proposed dose limits. The maximum lifetime risk of early death due to inhalation of transuranics at these limits is eight per 100,000 exposed, while that due to ingestion is five per 100,000 persons.

Lung Cancer and Radon Exposure

EPA/ORP reviewed new information relevant to estimates of the potential increase in lung cancer due to radioactive radon gas in residential structures. This review took into account recent health effects data from a number of different countries on underground uranium miners exposed to relatively low levels of radon daughters. Observed results are consistent with a linear association between radon exposure and lung cancer (i.e., the number of cancers is in direct proportion to the dose).

Using a linear relationship, EPA estimates that lung cancer mortality might be increased from two to five percent for each cumulative working month of exposures to radon daughter products. This method of estimation suggests that about four to eight percent of the current incidence of lung cancer in the general population could be associated with inhalation of the radon daughters which are part of natural background radiation. These estimates are highly uncertain, and additional ones are expected as part of the current National Academy of Sciences BEIR review. (See Ellett, William H., "Exposure to Radon Daughters and the Incidence of Lung Cancer," presented at the American Nuclear Society Meeting, San Francisco, CA (December 1, 1977).)

Long Term Effects of Coal and Nuclear Power Generation

At the Seminar on Nuclear Power in Oslo, Norway, EPA/ORP presented the results of a study comparing radiological health risks associated with coal and nuclear generated electrical power. (See Mills, W.A. and W.H. Ellett, "Long Term Effects of Low Level Radioactive Materials in the Environment" (December 5-7, 1977).) Major conclusions of the study were:

1. Both the combustion of coal and the fission of uranium for electric power generation result in the release of long half-life radioactive materials into the environment. In either case these effluents can be retained if sufficient effort is made to do so.

2. Assessed in terms of risk of cancer deaths for individuals living in the vicinity of such power plants, the radiological impacts are very nearly the same and of the order of one in a million over a lifetime.

3. A distinct difference between the dose commitments of coal and nuclear is that much of nuclear's impact is a result of worldwide distribution, while coal's impact is more local. The major portion of the worldwide commitment from nuclear power generation arises from the releases of radon and carbon-14.

4. Only the planned release of radioactive materials was considered in this comparison; before complete comparisons can be made, consideration must also be given to nonradioactive pollutants from fossil fuels and long term waste retention for the nuclear fuel cycle. Large scale accidents should also be included.

5. For coal combustion, the risks due to nonradioactive pollutants may outweigh those due to the radioactive pollutants, but information on this is still incomplete.

Radon Health Effects Modeling

EPA/ORP participated in a Radon Workshop held at the ERDA Health and Safety Laboratory in February 1977, and presented both the results on radon and lung cancer discussed above and a paper on health effects modeling. The EPA/ORP presentation outlined some of the parameters which relate exposure to radioisotope, the concentration of aerosol particles of respirable size, the relative humidity or degree of water saturation, the relative rate of movement of the atmosphere, and the temporal pattern of changes. It also showed how collection of these data would improve health effects modeling for exposure to radon and radon daughters. (See Nelson, Neal S., "Atmospheric Characteristics Essential for Health Effects Modeling," presented at the Radon Workshop, ERDA Health and Safety Laboratory, New York, New York, (February 1977).)

Computer Code for Risk Analysis

EPA/ORP developed a computer code for use in risk analysis, called Cohort Analysis of Increased Risks of Death (CAIRD). It can be used to calculate estimates of the health effects in a hypothetical population due to exposure to incremental risks such as exposure to radiation, and takes into account the age distribution of both the normal death rate and that of the added risk. In the case of radiation, the most serious somatic risk is death from a radiation induced cancer. Since these cancers do not generally develop until many years after exposure, other causes of death may intervene and take the lives of those otherwise destined to die from cancer. These two considerations, the temporal distribution of induced cancers and competing risks of death, are accounted for in the code. CAIRD generates a life table modified on the basis of the incremental probabilities of death associated with an increased risk; a comparison with an appropriate reference table yields measurements of the incremental risk's impact on the subject population.

Ocean Disposal Studies

DOE began to investigate the possibilities of disposing of high level waste by emplacing it under the ocean floor in a geologically stable, biologically inactive region. Among other aspects, detailed assessments were conducted of deep ocean sediments, and deep ocean and bottom dwelling biological communities were characterized to determine biological effects and possible concentration mechanisms and transport pathways.

APPENDIX A

SUMMARY OF LAWS ENACTED BY STATES DURING 1976

The following is a summary of laws relating to the nuclear regulatory program which were enacted by the States during the 1976 legislative session, compiled by the Nuclear Regulatory Commission.

ENERGY AGENCY

ARKANSAS H-286. Creates a State Energy Conservation and Policy Office to carry out energy-related activities, including developing supply and demand projections, monitoring existing policies, recommending legislation, and carrying out energy-related Federal programs. (Signed by Governor 2/7/77)

MINNESOTA H-522. Extends the life of the Energy Agency to June 30, 1983; and includes "any nuclear fuel processing or nuclear waste storage or disposal facility" in the definition of large energy facility. (Signed by Governor 6/2/77)

NEBRASKA H-232. Creates a State Energy Office which will serve as the central agency for the collection of energy data within the State; and the discharge of various energy-related functions, including a continuing assessment of the trends in the development of all forms of energy. (Signed by Governor 5/16/77)

NEW JERSEY S-3179. Abolishes the Department of Public Utilities and transfers its duties to the Board of Public Utilities within the Department of Energy (DOE). Gives the State DOE jurisdiction coextensive with that of all State agencies on the siting of an energy facility. Establishes an Energy Facility Review Board to settle differences among State agencies with respect to granting permits for the construction or location of an energy facility. (Signed by Governor 7/11/77)

NEW MEXICO H-12. A comprehensive bill consolidating the State's energy, coal, oil, mining, and geological functions and agencies into a single, unified Energy and Minerals Department. The Public Service Commission will be administratively attached to the Department. The Department's responsibilities will include the administration of State laws governing extractive resources, such as uranium, and the formulation and maintenance of a statewide plan for the siting, production, and processing of fuel and power. (Signed by Governor 4/7/77)

NORTH CAROLINA H-150. Transfers the Energy Division and the Energy Policy Council from the Department of Military Affairs to the Department of Commerce. (Ratified 2/22/77)

TEXAS S-1172. Creates the Texas Energy Advisory Council to formulate, continually reassess and modify a State energy policy for recommendation to the legislature and governor. (Signed by Governor 6/16/77)

SITING

ARKANSAS H-664. Amends the 1973 Act to require, among other things, that an application for a certificate of environmental compatibility and public need for the construction of a major utility facility include an environmental impact statement, an analysis of the economic or financial impact on the applicant and local community, and the estimated costs to the consumer. (Signed by Governor 3/30/77)

IDAHO HCR-31. A House Concurrent Resolution requesting the Public Utilities Commission to report by June 1, 1977 its findings concerning minimum environmental criteria for potential power plant sites, to rank the existing 21 potential sites which it already has on file. Thereafter, any new sites, as well as changes in standards or guidelines, will be reported at the beginning of each legislative session. (Adopted 3/18/77)

LOUISIANA SCR-82. A Senate resolution memorializing the U.S. Congress to request NRC to inform the Governors of States within the affected radius of a proposed nuclear facility prior to the issuance of a license authorizing its construction. (Adopted 7/11/77)

MAINE H-1388. Prohibits construction of nuclear power plants within the State unless the PUC finds that the "U.S. Government, through its authorized agency, has identified and approved a demonstrable technology or means for the disposal of high-level nuclear waste" and that adequate facilities will be in operation at the time they are needed. Other governmental entities which grant permits, licenses, approvals or authorizations for construction of nuclear power plants may process the applications, subject to the PUC's granting of certification. (Signed by Governor 6/22/77)

MINNESOTA S-896. Amends Minnesota statutes relating to power plant site and transmission line route selection authority, which is vested in the Environmental Quality Board. Requires the Board to publish an inventory of acceptable future power plant sites. Applications for construction of power plants have to contain at least two alternative sites. (Signed by Governor 6/2/77)

MONTANA H-542. Amends the current Major Facility Siting Act to allow a potential applicant for a siting certificate to file a notice of intent at least one year prior to the actual filing of the application. This will entitle the applicant to a 5% reduction in the filing fee. (Signed by Governor 3/29/77)

WASHINGTON S-2910. Provides that the Chairman of the Energy Facility Siting Council be appointed by the Governor for a term paralleling the Governor's. Empowers the Council to develop and apply environmental and ecological guidelines in the construction and operation of energy facilities. Governor Ray vetoed several sections, including local control over land use for energy facilities and prohibition of State preemptions in this area. (Signed by Governor 7/15/77)

WYOMING H-424. Requires a certificate of convenience and necessity, issued by the Public Service Commission, before a public utility may begin construction of a power line, plant or system. (Signed by Governor 2/28/77)

WYOMING S-29. Before a siting permit may be issued by the Industrial Siting Council, the State engineer must prepare an opinion as to the quantity of water available for the proposed facility. His opinion is binding upon the Siting Council for the purposes of issuing an industrial siting permit, and must be reviewed by the PSC prior to its issuance of a certificate of public convenience and necessity. Designates the Department of Environmental Quality as the agency to monitor the operations of all facilities which have been granted State siting permits to ensure compliance with the conditions of the permit. (Signed by Governor 2/23/77)

STUDIES

ARKANSAS HR-46. Requests a legislative study of the feasibility of creating a Utility Facility Finance Authority (as proposed in H-827) and its possible impact on the conservation, costs and supply of energy in the State. (Adopted 3/10/77)

CALIFORNIA A-77. Authorizes the allocation of up to one million dollars for the California Energy Commission to conduct research on undergrounding and berm containment of nuclear reactors. (Signed by Governor 5/18/77)

CALIFORNIA A-1852. Amends A-2820, one of the three nuclear laws enacted last year, which imposed a moratorium on nuclear plant construction until the Energy Commission found that adequate technology and facilities exist to reprocess spent fuel. This law requires the Energy Commission by January 16, 1978, to transmit to the legislature a determination as to whether the findings required by A-2820 can be made at that time. In the event that the findings cannot be made, the Commission is to include a recommendation as to whether existing applications for facilities should be exempt from the requirement. (Signed by Governor 9/28/77)

GEORGIA SR-99. Creates a Power Plant Siting Study Committee to develop legislation to streamline the State's laws and regulations. A report is due to the legislature prior to the convening of its 1978 session. (Adopted 3/4/77)

LOUISIANA SCR-84. A resolution requesting the State Senate and House Committees on Natural Resources to review the results of a study, conducted by the State Division of Radiation Control, "relative to the facts and circumstances surrounding the construction and use of nuclear reactors" in Louisiana. A report is due prior to the convening of the 1978 session. (Adopted 7/11/77)

MASSACHUSETTS S-1803. Extends until January 25, 1978, the special legislative committee which is studying power and its health and safety effects. (Adopted 6/20/77)

NEW MEXICO HJM-7. Directs the Energy Resources Board to compare the State energy-related licensing and permit fee systems with the cost of State regulation of energy and make recommendations for changes in the licensing and permit structures and fees to the legislature by 12/1/77. (Signed by Governor 3/18/77)

NEW MEXICO H-10. Abolishes the State agencies relating to health and the environment, including the health and social services department and the environmental improvement agency; and establishes a Health and Environment Department to exercise the functions formerly vested in those agencies. (Signed by Governor 4/7/77)

NEW MEXICO H-218. Creates a Federal Lands Action Group to "review the impact of Federal land ownership and Federal land policies on energy development in New Mexico, considering, in particular, the implications of the Federal statutes . . . upon uranium development in the State." A progress report is due to the legislature by 12/1/77. (Signed by Governor 4/7/77)

NEW MEXICO S-164. Directs the Environmental Improvement Agency to study the impact of uranium mine spoils, stock piles and mill tailings; and report its findings to the legislature by 12/1/77. (Signed by Governor 4/8/77)

OKLAHOMA HJR-1013. Commissions the State Department of Energy to conduct a study of alternative and supplemental energy sources, such as nuclear, for possible use by the State government. The study is to be completed by September 30, 1978. (Signed by Governor 6/14/77)

SOUTH DAKOTA SCR-17. Directs the Department of Environmental Protection to coordinate a review of the present statutory authority of concerned State agencies and submit legislative recommendations to control the mining of uranium in a manner consistent with public welfare. (Adopted 3/18/77)

VIRGINIA SJR-136. Establishes a joint subcommittee of the legislature to study licensing proceedings relating to the safety and security of nuclear power plants, and to determine whether any action by the General Assembly is appropriate or necessary. The report is due no later than November 1, 1977. (Adopted 2/28/77)

TRANSPORTATION

ARKANSAS S-327. Authorizes the Arkansas Department of Transportation to promulgate additional rules and regulations governing the transport of hazardous materials within the State, including labeling of containers, prior notification and emergency procedures. (Signed by Governor 3/15/77)

CONNECTICUT H-5358. Amends the State statutes regarding permits required for radioactive material to include "any shipment of radioactive material or waste which is carried by commercial carrier and which is required in 10 CFR or 49 CFR to have a placard." (Signed by Governor 5/19/77)

ILLINOIS S-245. Authorizes the Illinois Department of Transportation to regulate the transport of hazardous materials over the State's highways. (Signed by Governor 8/26/77)

MARYLAND S-511. Alters certain bonding requirements as a condition to the issuance of a permit for those engaged in the transportation and disposal of hazardous materials. (Signed by Governor 4/29/77)

NEBRASKA H-332. Requires the transporters of hazardous materials to carry liability insurance, and specifies the amount of the coverage. (Signed by Governor 3/21/77)

NORTH CAROLINA H-1431. Prohibits the transport of spent nuclear fuel over highways in North Carolina unless the transporter notifies the State Highway Patrol in advance. (Signed by Governor 6/30/77)

RADIATION CONTROL

MONTANA S-269. Amends State law to give the Board of Health and Environmental Sciences primary enforcement responsibility under the Federal Water Pollution Control Act. Expands the definition of "pollution" and "wastes" to include, among other things, radioactive material. (Signed by Governor 5/11/77)

NEW JERSEY A-1953. Amends the State Radiation Protection Act to require a "certificate of handling" of radioactive materials from the Department of Environmental Protection before anyone can transport, store, hold or detain radioactive materials, exceeding 20 curies, within the State. In addition, allows the DEP to recover the costs it incurs from those persons responsible for the radioactive material in the event of a threat or a discharge of radioactivity. (Signed by Governor 9/26/77)

RHODE ISLAND H-5555. Amends the State law to include a chapter entitled "Hazardous Substances Act." Prescribes the actions to be taken (such as packaging and labeling) to minimize dangers from all hazardous substances, including radioactive materials. (Signed by Governor 5/6/77)

VERMONT H-80. Amends the current radiation control law to define radioactive material and nonionizing radiation and to include that material in the State permit system. (Signed by Governor 4/27/77)

WASTE MANAGEMENT

CALIFORNIA A-1593. Revises the State code to require the State Department of Health to issue regulations and permits governing the transport, handling, processing, storage or disposal of hazardous wastes. (Signed by Governor 9/22/77)

COLORADO SM-3. Memorializes the U.S. Congress, the President and ERDA to exclude Colorado from consideration as a potential site for a high-level radioactive waste repository. (Adopted 6/3/77)

HAWAII H-199. Requires a permit for release of wastes and pollutants, which include radioactive material, into the air or water. (Signed by Governor 5/31/77)

ILLINOIS H-1739. Authorizes the Public Health Department to assess fees for radioactive waste disposal, with the proceeds going into a trust fund for the perpetual care of the sites. (Signed by Governor 9/20/77)

KANSAS H-2559. Amends the Kansas Solid Waste Act to include the regulation of hazardous wastes. The Department of Health and Environment is authorized to adopt rules and regulations governing hazardous wastes "stored, collected, transported, processed, treated, recovered or disposed" within the State. (Signed by Governor 4/5/77)

LOUISIANA H-14. Prohibits the use of salt domes in Louisiana as temporary or permanent disposal sites for radioactive wastes. Requires prior notification of the House and Senate Natural Resources Committees and the Department of Natural Resources for suitability testing of salt domes and subsequent notification of the results of the studies so they can "determine the advisability of removing, continuing, or extending the prohibitions and limitations." (Signed by Governor 7/5/77)

LOUISIANA SCR-83. A Senate resolution memorializing the U.S. Congress to enact Federal legislation "to require the proper Federal agency to notify both the governor and the legislature of any State of the agency's intention to search for radioactive waste disposal sites within that State." (Adopted 7/11/77)

MINNESOTA H-1215. Prohibits the construction or operation of a "radioactive waste management facility" within Minnesota unless authorized by the legislature. Prohibits the transport of wastes into the State for disposal or storage unless authorized by the legislature, except that "radioactive wastes may be transported into the State for temporary storage for up to 12 months pending transportation out of the State." The act is effective immediately. (Signed by Governor 6/2/77)

MONTANA H-254. Prohibits the disposal in Montana of large quantities of radioactive materials produced in other States. (Signed by Governor 3/21/77)

NEVADA S-38. Transfers responsibility to the Department of Human Resources for the acquisition and maintenance of sites for the disposal of low-level radioactive materials. Authorizes the State Board of Health to establish licensing fee requirements for users of these sites. (Signed by Governor 3/20/77)

NEW HAMPSHIRE H-542. Establishes a State-wide solid waste management program. (Signed by Governor 7/18/77)

NEW MEXICO S-55. Bans until March 31, 1978, the import of radioactive materials for storage or disposal within the State. Charges the Environmental Improvement Agency with responsibility in various areas, including radiation control and radioactive material disposal. (Signed by Governor 3/31/77)

OREGON S-272. Bans the establishment or operation of radioactive material waste disposal facilities within the State. The previous ban would have expired January 1, 1978. (Signed by Governor 7/27/77)

SOUTH DAKOTA H-822. Bans the "containment, disposal or deposit of high-level nuclear wastes, radioactive substances or radioactively contaminated materials or the processing of high-level nuclear wastes" within the State unless prior approval is granted by the legislature. Exempts uranium ore and mill tailings from the provisions of the act. (Signed by Governor 4/16/77)

TEXAS H-1560. Authorizes the Texas Water Quality Board to regulate the discharge of waste or pollutants into any water within the State; however, no permits shall be issued authorizing the discharge of "any radiological, chemical, or biological warfare agent or high-level radioactive waste." (Signed by Governor 6/15/77)

VERMONT H-261. Bans the construction or establishment of a high-level radioactive waste repository within Vermont, unless the General Assembly approves it, through either a bill or a joint resolution. (Signed by Governor 4/26/77)

RESOLUTIONS

COLORADO HJR-1032. Memorializes the U.S. Congress to accelerate and broaden the research and development of nuclear fusion, and to increase the development of existing fossil and nuclear fuel technologies to bridge the time gap until fusion energy comes on line. (Adopted 5/25/77)

HAWAII SR-272. A Senate resolution citing delays up to six months on the part of physicians in Hawaii in obtaining license amendments from NRC, and requesting the Governor to petition NRC for a rule change to give priority to medical licensees, and to lessen the "extensive and repetitious paperwork" involved in seeking a license amendment. (Adopted 4/5/77)

MARYLAND HJR-80. Memorializes the U.S. Congress to foster the development of controlled nuclear fusion technology. (Signed by Governor 5/17/77)

NEVADA AJR-16. Memorializes the President against the premature closing of the Nevada test site; and requests the Federal Government to present a plan for conversion of the test site to another use to counterbalance the economic loss to Nevada. (Adopted 2/7/77)

PENNSYLVANIA HR-54. Urges the President and the U.S. Congress to restore funds for the development of the fast breeder reactor and nuclear fusion power. (Adopted 4/26/77)

TENNESSEE HJR-84. A House Joint Resolution stating that the General Assembly and Governor firmly support the continuation of the Clinch River Breeder Reactor project. (Adopted 4/7/77)

UTAH SCR-1. A Senate Concurrent Resolution, outlining the State's energy policy, which encourages the development of alternative energy sources, such as solar, geothermal, wind, and hydroelectric power. The development of nuclear resources will, at present, be confined to uranium mining, processing and waste disposal. (Signed by Governor 3/22/77)

URANIUM

MONTANA S-268. Suspends action on solution extraction of uranium from in-place deposits until April 1, 1978, unless the Board of Health and Environmental Sciences adopts rules regulating the process before that date. (Signed by Governor 5/10/77)

NEW MEXICO S-137. Imposes a severance tax on uranium on a sliding scale related to its price per pound, and sets a surtax on uranium ore having a value of $50 or more per pound. (Signed by Governor 3/31/77)

NEW MEXICO S-447. Amends the State Radiation Protection Act to give the Environmental Improvement Agency the power to add a 10-cent a pound fee to the first 100,000 pounds of yellowcake milled at each uranium mill. The money would be placed in a fund to continue monitoring and clean-up operations after the mills ceased operations. (Signed by Governor 4/7/77)

OHIO HJR-34. Memorializes the U.S. Congress to fulfill the commitments of two previous Presidents by authorizing the funding recommended to complete the expansion of the Portsmouth uranium enrichment facility. (Adopted 4/27/77)

TEXAS S-360. Prohibits electric facility "participating entities" from exercising the power of eminent domain to acquire land for the purpose of mining uranium and coal, drilling for oil and gas, etc. (Signed by Governor 4/29/77)

WYOMING H-187 & H-279. These laws increase the present State excise tax from 2% to 5.5% of the assessed valuation of the ore as it is mined. The new taxes are effective immediately, that is, they will be assessed against 1976 uranium production. (Signed by Governor 3/14/77)

MISCELLANEOUS

KANSAS S-152. Permits two or more cities to create a municipal energy agency to enter into agreements to purchase electricity. (Signed by Governor 4/21/77)

WASHINGTON H-852. Allows a State "operating agency" to amend a contract previously let for the construction of a nuclear plant in order to comply with applicable changes in State or Federal regulations or standards to improve the safety or feasibility of the project and expedite its completion. (Signed by Governor 5/16/77)

LEGEND

AB — Assembly Bill

HB — House Bill

SB — Senate Bill

HR — House Resolution

SR — Senate Resolution

HJR — House Joint Resolution

HCR — House Concurrent Resolution

SCR — Senate Concurrent Resolution

SJR — Senate Joint Resolution

APPENDIX B

LIST OF RADIATION PROTECTION PUBLICATIONS - 1977

EPA PUBLICATIONS

EPA Technical Reports

520/5-77-001	Radiological Survey Of Puget Sound Naval Shipyard, Bremerton, Washington And Environs PB 271 660
520/5-77-002	EPA Assessment of Fallout In The United States From Atmospheric Nuclear Testing On September 26 And November 17, 1976 By The People's Republic of China
520/4-77-003	Considerations Of Health Benefit-Cost Analysis For Activities Involving Ionizing Radiation Exposure And Alternatives (Beir II Report)
520/4-77-005	Radiation Protection Activities 1976 PB 273 469/AS
520/3-77-006	Summary Of Radioactivity Released In Effluents From Nuclear Power Plants From 1972 Through 1975
520/1-77-009	Radiological Quality Of The Environment In The United States 1977 PB 274 229/AS
520/6-77-010	Effects Of Phosphate Mineralization And The Phosphate Industry On Radium-226 In Ground Water Of Central Florida
520/3-77-012	Summary Of Radioactivity Released In Effluents From Nuclear Power Plants From 1973 Through 1976
520/4-77-013	Assessment Of Carbon-14 Control Technology And Costs For The LWR Fuel Cycle
520/4-77-015	Natural Radioactivity Contamination Problems
520/4-77-016	Proposed Guidance On Dose Limits For Persons Exposed To Transuranium Elements In The General Environment
600/7-77-082	Potential Radioactive Pollutants Resulting From Expanded Energy Programs
902/4-77-010	Summary Report On The Low-Level Radioactive Waste Burial Site, West Valley, New York (1963-1975)

EPA Technical Notes

ORP/CSD-77-1	Proceedings: A Workshop On Issues Pertinent To The Development Of Environmental Protection Criteria For Radioactive Wastes

ORP/CSD-77-2	Proceedings: A Workshop On Policy And Technical Issues Pertinent To The Development Of Environmental Protection Criteria For Radioactive Wastes
ORP/CSD-77-4	Plutonium Inhalation Dose (PAID) A Code For Calculating Organ Doses Due To The Inhalation And Ingestion Of Radioactive Aerosols
ORP/EAD 76-5	Environmental Radio-Frequency Field Strengths: Miami, Florida
ORP/EAD 76-7	Field Strength Measurements Of Microwave Oven Leakage At 915 MHz
ORP/EAD 77-2	An Investigation Of Broadcast Radiation Intensities At Mt. Wilson, California PB 275 040/AS
ORP/EAD 77-3	An Analysis Of Radar Exposure In The San Francisco Area PB 273 188/AS
ORP/LV 77-1	Outdoor Radon Study (1974-1975): An Evaluation of Ambient Radon-222 Concentrations In Grand Junction, Colorado PB 266 297
ORP/LV-77-2	Radiological Survey At The Inactive Uranium Mill Site Near Riverton, Wyoming
ORP/LV 77-3	Radiological Surveys Of Idaho Phosphate Ore Processing—The Thermal Process Plant
ORP/LV 77-4	Generalized Model Of The Time Dependent Weathering Half-Life Of The Resuspension Factor
ORP/TAD 77-1	Evaluation Of Tritium Recycle And Buildup In A Pressurized Water Reactor
ORP/TAD 77-2	An Analysis Of Low-Level Solid Radioactive Waste From LWRs Through 1975
ORP/TAD 77-3	Characterization Of Selected Low-Level Radioactive Waste Generated By Four Commercial Light-Water Reactors

Environmental Radiation Data

Four quarterly reports of monitoring data are available from EPA's Eastern Environmental Radiation Facility, Montgomery, Alabama 36109.

BRH TECHNICAL PUBLICATIONS

FDA 77-8013	The Mean Active Bone Marrow Dose to the Adult Population of the United States from Diagnostic Radiology (GPO 017-015-00119-9, $1.05) (PB 262 909/AS, mf only).
FDA 77-8015	Progress in Radiation Protection 1975.
FDA 77-8017	Nationwide Evaluation of X-Ray Trends: Organ Dose Index System - Radiographic Field Survey Procedures Handbook (GPO 017-015-00121-1, $0.80, $1.00).

FDA 77-8018	Photographic Quality Assurance in Diagnostic Radiology, Nuclear Medicine, and Radiation Therapy. Volume II – Photographic Processing, Quality Assurance and The Evaluation of Photographic Materials (GPO 017-015-00123-7, $2.20) (PB 267 498/AS, mf only).
FDA 77-8020	Patient Exposure from Diagnostic X-Rays: An Analysis of 1972-1974 NEXT Data (PB 267 741/AS, $4.00).
FDA 77-8021	8th Annual National Conference on Radiation Control: Radiation Benefits and Risks: Facts, Issues, and Options (GPO 017-015-00126-1, $5.50) (PB 267 317/AS, mf only).
FDA 77-8023	Radiological Health Training Resources – 1977 (supersedes FDA 75-8027).
FDA 77-8025	Guides for Naturally Occurring and Accelerator-Produced Radioactive Materials (NARM) (GOP 017-015-00140-7, $2.20) (PB 272 303/AS, mf only).
FDA 77-8026	Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. (GPO 017-015-00137-7, $5.25) (PB 272 906/AS, mf only).
FDA 77-8027	Directory of Personnel Responsible for Radiological Health Programs (supersedes FDA 77-8016).
FDA 77-8028	Diagnostic Radiology Quality Assurance Catalog (GPO 017-015-00127-0, $4.00) (PB 271 248/AS, mf only).
FDA 77-8029	Course Manual for Machine Sources of X-Rays (GS-461) (GPO 017-015-00131-8, $4.00) (PB 272 011/AS, mf only) (supersedes FDA 73-8026).
FDA 77-8030	Course Manual for X-Ray Measurements (GS-462) (GPO 017-015-00130-0, $3.50) (PB 272 012/AS, mf only) (supersedes FDA 73-8027).
FDA 77-8031	Course Manual for X-Ray Applications (GS-463) (GPO 017-015-00132-6, $3.00) (PB 272 010/AS, mf only) (supersedes FDA 73-8028).
FDA 77-8032	The Bureau of Radiological Health ... A Look at FDA's Program to Protect the American Consumer from Radiation (GPO 017-015-00128-8, $1.20) (PB 272 869/AS, mf only).
FDA 77-8033	BRH Publications Index (GPO 017-015-00129-6, $4.25) (PB 271 734/AS, mf only).
FDA 77-8034	Report of State and Local Radiological Health Programs, FY 1976 (PB 273 392/AS, $5.25).
FDA 77-8035	The Developing Role of Short-Lived Radionuclides in Nuclear Medicine (GPO 017-015-00139-3, $2.00) (PB 272 298/AS, mf only).
FDA 77-8036	Second Image Receptor Conference: Radiologic Film Processing (GPO 017-015-00134-2, $3.00).

FDA 77-8039	Exposure and Processing Guides for Dental Radiography (GPO 017-015-00135-1, $1.20).
FDA 77-8042	CSU-FDA Collaborative Radiological Health Laboratory Annual Report 1976 (PB 273 560/AS, $6.50).
FDA 78-8015	Progress in Radiation Protection 1976.
FDA 78-8043	A Review of the Use of Ionizing Radiation for the Treatment of Benign Diseases (GPO 017-015-00141-5, $2.10) (PB 274 032/AS, mf only).
FDA 78-8045	Radiation Protection During Medical X-Ray Examinations - Part 6, Quality Control for the Automatic Film Processor.
FDA 78-8048	Symposium on Biological Effects and Characterizations of Ultrasound Sources.

1977 Annual Report on Administration of the Radiation Control for Health and Safety Act of 1968
Public Law 90-602 April 1, 1978

DOE PUBLICATIONS

DOE Technical Reports

ERDA 77-1	A NATIONAL PLAN FOR ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION. June 1977 GPO $2.00
ERDA 77-10	REPORT OF THE NUCLEAR WEAPON TRANSPORTATION SAFETY HAZARDS EVALUATION GROUP (CLASSIFIED)
ERDA 77-12	[THE TENNESSEE VALLEY REGION—A YEAR 2000 PROFILE and THE TENNESSEE VALLEY REGION STUDY: POTENTIAL YEAR 2000 RADIOLOGICAL DOSE TO POPULATION RESULTING FROM NUCLEAR FACILITY OPERATION.]
ERDA 77-17	BENEFICIAL USE OF WASTE NUCLEAR ISOTOPES: 137 CESIUM IRRADIATION TREATMENT OF MUNICIPAL SLUDGE AND COMPOST. An Executive Summary Report. Jan. 1977 NTIS
ERDA 77-24	A GUIDE FOR ENVIRONMENTAL RADIOLOGICAL SURVEILLANCE AT ERDA INSTALLATIONS. Mar. 1977 NTIS
ERDA 77-29	EIGHTH ANNUAL REPORT OF RADIATION EXPOSURES FOR ERDA AND ERDA CONTRACTOR EMPLOYEES—1975. Apr. 1977 NTIS
ERDA 77-34 [NUREG 0095]	JOINT ERDA-NRC TASK FORCE ON SAFEGUARDS. FINAL REPORT, JULY 1976. (Unclassified Version) Feb. 1977 NTIS
ERDA 77-41/9	ERDA HEADQUARTERS REPORTS: JANUARY 1975–SEPTEMBER 1977. Sep. 1977
ERDA 77-43	ALTERNATIVES FOR LONG-TERM MANAGEMENT OF DEFENSE HIGH-LEVEL RADIOACTIVE WASTE. Idaho Chemical Processing Plant, Idaho Falls, Idaho
ERDA 77-44	ALTERNATIVES FOR LONG-TERM MANAGEMENT OF DEFENSE HIGH-LEVEL RADIOACTIVE WASTE. Hanford Reservation, Richland, Washington
ERDA 77-46	SURVEY OF UNITED STATES URANIUM MARKETING ACTIVITY. May 1977 NTIS
	INVENTORY OF FEDERAL ENERGY-RELATED ENVIRONMENT AND SAFETY RESEARCH FOR FY 1976.
ERDA 77-50/1	Vol. 1 — Executive Summary
ERDA 77-50/2	Vol. 2 — Catalog of Biomedical & Environmental Research Projects (2 parts)
ERDA 77-50/3	Vol. 3 — Catalog of Environmental Control Technology Research Projects
ERDA 77-50/4	Vol. 4 — Catalog of Operational Safety Research Projects. Apr. 1977 NTIS

ERDA 77-59	SURVEY OF URANIUM INDUSTRY VIEWS CONCERNING U.S. URANIUM RESOURCES AND U.S. URANIUM PRODUCTION. Apr. 1977 NTIS
ERDA 77-79	MANAGING THE SOCIOECONOMIC IMPACTS OF ENERGY DEVELOPMENT: A GUIDE FOR THE SMALL COMMUNITY. Sep. 1977 GPO
ERDA 77-90	ASSISTANCE FROM ENERGY DEVELOPERS: A NEGOTIATING GUIDE FOR COMMUNITIES
ERDA 77-91	MODELS AND METHODOLOGIES FOR ASSESSING THE IMPACT OF ENERGY DEVELOPMENT
ERDA 77-102	NUCLEAR ENGINEERING ENROLLMENTS AND DEGREES, 1976. July 1977 NTIS
ERDA 77-104	ENVIRONMENTAL MONITORING AT MAJOR U.S. ERDA CONTRACTOR SITES. Calendar Year 1976 (2 vols.)
ERDA 77-123	MATERIALS SCIENCES PROGRAMS — FY 1977
ERDA-1557D	DRAFT ENVIRONMENTAL IMPACT STATEMENT: COAL RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAM
ERHQ-0018	ANALYSIS OF ENERGY FUTURES FOR THE UNITED STATES

NRC PUBLICATIONS

NUREG-0020.	Operating Units Status Report (Gray Book). Office of Management Information and Program Control. Monthly. NTIS
NUREG-0025.	Monthly Inspection Summary Report. Office of Inspection and Enforcement. Monthly NTIS
NUREG-0030.	Construction Status Report of Nuclear Power Plants (Yellow Book).Office of Management Information and Program Control. Monthly. NTIS
NUREG-0040.	Licensee Contractor and Vendor Inspection Status Report (White Book). Office of Inspection and Enforcement. Quarterly. NTIS
NUREG-0090–5.	Report to Congress on Abnormal Occurrences. Office of Management Information and Program Control. Mar. 1977. 24 p. NTIS
NUREG-0090–6.	Report to Congress on Abnormal Occurrences: October – December 1976. Office of Management Information and Program Control. June 1977. 32 pp. NTIS
NUREG-0090–7.	Report to Congress on Abnormal Occurrences: January – March 1977. Office of Management Information and Programs Control. June 1977. 20 pp. NTIS
NUREG-0090–8.	Report to Congress on Abnormal Occurrences: April – June 1977. Office of Management Information and Program Control. Sept. 1977. 28 pp. NTIS

NUREG-0090-9. Report to Congress on Abnormal Occurrences: July - September 1977. Office of Management Information and Program Control. November 1977. NTIS

NUREG-0135, Vol. 4, No. 6. Water Reactor Safety Research Status Summary Report (Buff Book). Office of Management Information and Program Control. Bimonthly. NTIS

NUREG-0141. An Assessment of Some Safeguards Evaluation Techniques. Gref, L. G. and Rosengren, J. W. Prepared for USNRC Office of Nuclear Regulatory Research (Safeguards, Fuel Cycle and Environmental Research) by R & D Associates. Contract No. A3043. Feb. 1977. 164 p. NTIS

NUREG-0148. LMFBR Fuel Analysis, Task C: Reliability Aspects of LMFBRs, Final Report for the Period July 1, 1975 - September 30, 1976. Kastenberg, W. E., *et al.* Prepared for USNRC Office of Nuclear Reactor Regulation (Project Management) by University of California at Los Angeles, Energy and Kinetics Department. Contract AT(49-24)-0159. Jan. 1977. 144 p. NTIS

NUREG-0150. Socioeconomic Impacts: Nuclear Power Station Siting. Prepared for USNRC Office of Nuclear Regulatory Research (Safeguards, Fuel Cycle and Environmental Research) by Policy Research Associates. Contract AT(49-24)-0361. June 1977. 148 pp. NTIS

NUREG-0154. Exposure of Airport Workers to Radiation from Shipments of Radioactive Materials — A Review of Studies Conducted at Six Major Airports. Prepared for USNRC Office of Standards Development (Engineering Standards) by Shapiro, J. Contract No. DR-75-1505. Jan. 1977. 32 p. NTIS

NUREG-0156. The White-Collar Challenge to Nuclear Safeguards. Edelhertz, H. and Walsh, M. Prepared for USNRC Office of Nuclear Regulatory Research (Safeguards, Fuel Cycle and Environmental Research) by Battelle Human Affairs Research Center. Contract No. NRC FIN B2082. Jan. 1977. 84 p. NTIS

NUREG-0170, Vol. 1. Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes. Office of Standards Development (Engineering Standards). Dec. 1977. 351 pp. NTIS

NUREG-0172. Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake. G. R. Hoenes and J. K. Soldat. Prepared for USNRC Office of Standards Development (Siting, Health and Safeguards Standards) by Battelle Pacific Northwest Laboratories. Contract B21446. November 1977. 112 pp. NTIS

NUREG-0179. Regulatory and Other Responsibilities as Related to Transportation Accidents. Barker, R. F. Office of Standards Development (Engineering Standards). June 1977. 15 pp. NTIS

NUREG-0180. Early Site Reviews for Nuclear Power Facilities. Office of Nuclear Reactor Regulation (Site Safety and Environmental Analysis). May 1977. 48 pp. NTIS

NUREG-0185. Annual Report of Contract Research for the Metallurgy and Materials Research Branch, Division of Reactor Safety Research, FY 76. Office of Nuclear Regulatory Research (Reactor Safety Research). Jan. 1977. 232 p. NTIS

NUREG-0192-1.	First Annual Progress Report on Analytical and Experimental Studies of Nonlinear System Modeling and Scaling. Masri, S. F. Prepared for USNRC Office of Nuclear Regulatory Research (Reactor Safety Research) by University of Southern California. Contract No. AT(49-24)-9262. Feb. 1977. 280 p. NTIS
NUREG-0194.	Calculations of Radiological Consequences from Sabotage of Shipping Casks for Spent Fuel and High-Level Waste. Office of Nuclear Material Safety and Safeguards (Fuel Cycle and Material Safety). May 1977. 24 pp. NTIS
NUREG-0195.	Improving Regulatory Effectiveness in Federal/State Siting Actions. Office of State Programs. June 1977. 192 pp. NTIS
NUREG-0197.	State Regulatory Activity Involved in Need for Power: Final Report. Nassikas, J. N. Prepared for USNRC Office of State Programs by Cox, Langford and Brown. Contract DR-77-0219. June 1977. 60 pp. NTIS
NUREG-0199.	Environmental Planning and the Siting of Nuclear Facilities: The Integration of Water, Air, Coastal, and Comprehensive Planning into the Nuclear Siting Process: Final Report. Noble, J. B., *et al*. Prepared for USNRC Office of State Programs by Center for Natural Areas. Contract DR-77-0539. June 1977. 224 pp. NTIS
NUREG-0200.	Federal/State Regulatory Permitting Actions in Selected Power Station Licensing Cases. Prepared for USNRC Office of State Programs by the Energy Program of the National Governors' Conference, J. Baroff, Principal Investigator. Contract AT(49-24)-0327. Sept. 1977. 128 pp. NTIS
NUREG-0201.	Water Supplies and the Nuclear Licensing Process. Davenport, F. S. Prepared for USNRC Office of State Programs by U.S. Water Resources Council. Contract NRC-06-77-068. July 1977. 148 pp. NTIS
NUREG-0202.	Nuclear Power Plant Licensing: A New England Perspective: Final Report. Clark, P. B., *et al*. Prepared for USNRC Office of State Programs by Center for Energy Policy, Inc. Contract DR-77-0543. June 1977. 84 pp. NTIS
NUREG-0203.	State and Local Planning Procedures Dealing with Social and Economic Impacts from Nuclear Power Plants: Final Report. Curry, M., *et al*. Prepared for USNRC Office of State Programs by Battelle Memorial Institute. Contract 189 No. 300A01046. June 1977. 272 pp. NTIS
NUREG-0207.	Interim Format and Content for a Physical Security Plan for Nuclear Power Plants. Office of Nuclear Reactor Regulation (Operating Reactors). April 1977. 52 p. Avail. at NRC
NUREG-0217.	NRC Task Force Report on Review of the Federal/State Program for Regulation of the Commercial Low-Level Radioactive Waste Burial Grounds. Office of Nuclear Material Safety and Safeguards and Office of State Programs. Mar. 1977. 69 p. NTIS
NUREG-0217.	Supp. 1. Analysis of Public Comments: NRC Task Force Report on Review of the Federal/State Program for Regulation of Commercial Low-Level Radioactive Waste Burial Grounds. Office of Nuclear Material Safety and Safeguards and Office of State Programs. March 1977. 20 pp. NTIS

NUREG-0218. Radioactive Materials Released from Nuclear Power Plants — 1975. Office of Management Information and Program Control. Mar. 1977. 168 p. NTIS

NUREG-0227. Nuclear Power Plant Operating Experience, 1974-1975. Office of Management Information and Program Control. April 1977. 508 p. NTIS

NUREG-0240. The NRC Low-Level/Waste Management Program. Office of Nuclear Material Safety and Safeguards. November 1977. 36 pp. NTIS

NUREG-0252. The Environmental Effects of Using Coal for Generating Electricity. Dvorak, A. J., *et al*. Prepared for USNRC Office of Nuclear Reactor Regulation (Site Safety and Environmental Analysis) by Argonne National Laboratory, Division of Environmental Impact Studies. ERDA Contract W-31-109-ENG-38. June 1977. 232 pp. NTIS

NUREG-0267. Principles and Practices for Keeping Occupational Radiation Exposures at Medical Institutions as Low as Reasonably Achievable. Office of Standards Development (Siting, Health, and Safeguards Standards) Dec. 1977. 56 pp. Available from NRC

NUREG-0278, Vol. 1. Technology, Safety and Costs of Decommissioning a Reference Nuclear Fuel Reprocessing Plant. Schneider, K. J., Jenkins, C. E., and others. Prepared for USNRC Office of Standards Development (Engineering Standards) by Battelle Pacific Northwest Laboratory. Contract EY-76-C-06-1830. October 1977. 270 p. NTIS

NUREG-0292. Nuclear Power Plant Licensing: Opportunities for Improvement: Study Group Report. Denton, H. R. Office of Nuclear Reactor Regulation (Site Safety and Environmental Analysis). June 1977. 116 pp. NTIS

NUREG-0301. Regulation of Naturally Occurring and Accelerator-Produced Radioactive Materials: A Task Force Review. Nussbaumer, D. A., and others. Office of Nuclear Material Safety and Safeguards/Office of State Programs. July 1977. 76 pp. NTIS

NUREG-0302. Public Regional Meetings to Discuss Regulations (10 CFR Part 21) for Reporting of Defects and Noncompliance, July 12-26, 1977. Office of Inspection and Enforcement (Reactor Construction Inspection). July 1977. 40 pp.

NUREG-0302, Rev. 1. Remarks Presented at Public Regional Meetings to Discuss Regulations (10 CFR Part 21) for Reporting of Defects and Noncompliance. Office of Inspection and Enforcement. October 1977. 168 pp. NTIS

NUREG-0317, Vol. 1. VISA: A Method for Evaluating the Performance of Integrated Safeguards Systems at Nuclear Facilities. Donnelly, H., and others. Prepared for USNRC Office of Nuclear Regulatory Research (Safeguards/Fuel Cycle and Environmental Research) by Science Applications, Inc. Contract AT(49-24)-0332. August 1977. 132 pp. NTIS

NUREG-0317, Vol. 2. VISA: A Method for Evaluating the Performance of Integrated Safeguards Systems at Nuclear Facilities. Donnelly, H., and others. Prepared for USNRC Office of Nuclear Regulatory Research (Safeguards/Fuel Cycle and Environmental Research) by Science Applications, Inc. Contract AT(49-24)-0332. August 1977. 152 pp. NTIS

NUREG-0321. A Study of the Nuclear Regulatory Commission Quality Assurance Program. Prepared for USNRC Office of Nuclear Reactor Regulation (Project Management) by Sandia Laboratories. ERDA Contract AT(29-1)-789. August 1977. 124 pp. NTIS

NUREG-0322.	Ninth Annual Occupational Radiation Exposure Report, 1976. Brooks, B. G. Office of Management Information and Program Control. October 1977. 48 pp. NTIS
NUREG-0325.	U.S. Nuclear Regulatory Commission Functional Organization Charts. Office of Administration (Technical Information and Document Control). August 1977. 44 pp. NTIS
NUREG-0326.	Workshop Material for State Review of NRC Site Suitability Criteria for High-Level Waste Repositories. Office of Nuclear Material Safety and Safeguards (Fuel Cycle and Material Safety). Sept. 1977. 36 pp. NTIS
NUREG-0330.	Advanced Reactor Safety Research Status (Buff Book I). Office of Management Information and Program Control. Bimonthly. NTIS
NUREG-0332.	Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives. Gotchy, R. L. Office of Nuclear Reactor Regulation (Site Safety and Environmental Analysis). 30 pp. November 1977. Available at NRC
NUREG-0334.	Executive Summary of Safeguards Systems Concepts for Nuclear Material Transportation. Baldonado, O. C., and others. Prepared for USNRC Office of Nuclear Regulatory Research (Safeguards, Fuel Cycle and Environmental Research) by System Development Corporation. Contract AT(49-24)-0333. October 1977. 16 p. NTIS
NUREG-0335.	Safeguards System Concepts for Nuclear Material Transportation. Baldonado, O. C., and others. Prepared for USNRC Office of Nuclear Regulatory Research (Safeguards, Fuel Cycle and Environmental Research) by System Development Corporation. Contract AT(49-24)-0333. October 1977. 252 p. NTIS
NUREG-0370.	NRC Testimony Before the Subcommittee on Nuclear Regulation of the Committee on Environment and Public Works, U.S. Senate. USRNC. October 1977. 48 pp. NTIS
NUREG-0392.	Review and Evaluation of the NRC Safety Research Program. Advisory Committee on Reactor Safeguards. Dec. 1977. 84 pp. NTIS
NUREG-0394.	Impact of Offshore Nuclear Generating Stations on Recreational Behavior. Prepared for USNRC Office of Nuclear Regulatory Research (Safeguards/Fuel Cycle and Environmental Research) by Florida State University. Contract AT(49-24)-0320. Dec. 1977. 145 pp. NTIS

WHERE TO WRITE FOR INFORMATION

Publications with a GPO number may be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; those with an NTIS number may be ordered from the National Technical Information Service, Springfield, Va. 22161. Some, as noted, are available in microfilm or microfiche (mf). Publications with neither a GPO nor an NTIS number may be ordered directly from the agencies which publish them, at the address below:

Bureau of Radiological Health
BRH Technical Information
5600 Fishers Lane
Rockville, Maryland 20857

Department of Energy
Office of Public Affairs
20 Massachusetts Ave., NW
Washington, D.C. 20545

Environmental Protection Agency
Office of Radiation Programs
(AW-460)
401 M Street, SW
Washington, D.C. 20460

Nuclear Regulatory Commission
Document Control
Washington, D.C. 20555

APPENDIX C

NON-GOVERNMENT STANDARDS SETTING BODIES

American National Standards Institute (ANSI)

ANSI acts as a clearinghouse to coordinate standards development in the private sector by about 20 pertinent professional and technical societies. The actual drafting of standards is done by experts sitting on society sponsored panels. Since 1975, the responsibility of the ANSI Secretariat for the Main Committee on Radiation Protection has been assumed by the Health Physics Society (see below).

There are presently twelve ANSI Standards in force. These include standards for administrative practices in radiation monitoring, specification of standards source terms for nuclear power plants for environmental dose design calculations, guides for radiation protection in uranium mines, air sampling criteria, and performance specifications for instrumentation. Copies of these Standards are available from the American National Standards Institute, 1430 Broadway, New York, New York 10018.

In addition, about twenty other standards are in various stages of development. These include standards on performance specifications for thermoluminescent dosimeters, monitoring of occupational exposure, several standards in the field of environmental contamination, and others dealing with contamination of equipment and facilities. A series of standards is also underway dealing with environmental radiation surveillance. Finally, a number of standards on internal dosimetry techniques are being prepared with respect to occupational exposures to activation and fission products, tritium, uranium, and plutonium. For further information, see M.E. Wrenn's paper "The U.S. National Voluntary Consensus Nuclear Standards Program in Radiation Protection (ANSI N-13)," presented at the International Radiation Protection Association, Paris, April 24-30, 1977.

National Council on Radiation Protection & Measurements (NCRP)

Six new reports were issued in 1977:

— "Radiation Protection Design Guidelines for 0.1–100 MeV Particle Accelerator Facilities" (51)

— "Cesium-137 from the Environment to Man: Metabolism and Dose" (52)

— "Review of NCRP Radiation Dose Limit for Embryo and Fetus in Occupationally Exposed Women" (53)

— "Medical Radiation Exposure of Pregnant and Potentially Pregnant Women" (54)

— "Protection of the Thyroid Gland in the Event of Releases of Radioiodine" (55)

— "Radiation Exposure from Consumer Products and Miscellaneous Sources" (56)

Any of these may be ordered from NCRP at 7910 Woodmont Avenue, Washington, D.C. 20014.

International Commission on Radiological Protection (ICRP)

The Commission submitted the following material on its 1977 activities, beginning with four reports which were published as numbers 1-4 of Volume 1 of the ICRP Annals:

— Radiation Protection in Uranium and other Mines. (ICRP Publication 24)

This report is concerned with the principles of monitoring and limitation of radiation exposure in uranium mines, taking account of the currently recommended limits. While the main intention of the report is to outline the protective measures necessary in uranium mines, much of the material in the report will necessarily be applicable also to other mines in which radon is found.

The report is divided into sections dealing with the operational limits of exposure, both for external and internal exposure, and for appropriate methods of monitoring these; with control measures and protective equipment; and with special operational decisions and medical surveillance.

The report includes three appendices in which there are detailed discussions, about the physical characteristics and behavior of radon and its daughters in a mine, suggested methods for measuring and the use of high efficiency respirators.

— The handling, storage, use and disposal of unsealed radionuclides in hospitals and medical research establishments. (ICRP Publication 25)

This report is a revision of the material previously issued in 1964 as ICRP Publication 5 — The handling and disposal of radioactive materials in hospitals and medical research establishments. The new report replaces the previous recommendations of the Commission given in ICRP Publication 5, and is primarily directed towards the competent national authorities. However, the information given in the report can also be used by the local medical and research institutions, and to some extent be applicable to other types of laboratories where radioactive substances are used. The report is concerned with the problems that arise owing to the use of unsealed radioactive substances in therapy, diagnosis and research. (Recommendations on the use of sealed sources have been given in ICRP Publications 15 and 21, now published as one volume.) Points considered include the following: protection of workers, patients, members of the public and in medical research; control of contamination and waste; monitoring; storage and transport; methods for dealing with leakage and various types of emergency. There are three appendices and ten tables.

— Recommendations of the International Commission on Radiological Protection. (ICRP Publication 26)

The report supersedes the Commission's basic recommendations that appeared in 1966 as ICRP Publication 9. During the past decade new information has emerged which has necessitated a review of the Commission's recommendations; the report results from the examination of such new information by the Commission and by its committees and task groups.

In the new recommendations the Commission emphasizes its system of dose limitation, the main features of which are that:

a. no practice shall be adopted unless its introduction produces a positive net benefit;

b. all exposures shall be kept as low as reasonably achieveable, economic and social factors being taken into account; and

c. the dose equivalent to individuals shall not exceed the limits recommended for the appropriate circumstances by the Commission.

The report begins with a short section on the objectives of radiation protection, followed by a discussion of some basic concepts of radiation protection, including the definition of terms used such as detriment, dose equivalent, and various forms of collective dose. Next, there is an extensive section on the radiobiological considerations underlying the Commission's recommendations; this includes consideration of dose-response relationships and a detailed quantitative review of the risk factors applicable to the various organs and tissues of the body. The Commission's system of dose limitation is then described in detail, and the recommended dose-equivalent limits for workers and members of the public are given. The report concludes with sections outlining the general principles of operational radiation protection and their application to the different types of exposure.

— Problems involved in developing an index of harm. (ICRP Publication 27)

In order to recommend appropriate limits for occupational or other exposure to radiation it is desirable to estimate the types and frequencies of harmful effects that may result. Moreover, in comparing the safety of an occupation involving exposure to radiation with the safety of other occupations, it is important to compare the total harm that may be caused by the radiation, both in those exposed and in their descendants, with the total harm involved in other occupations, whether by fatal or minor injury, occupational disease or the effects of mutagens in the environment.

This report, prepared for the International Commission on Radiological Protection by Sir Edward Pochin, discusses the difficulties of making an appropriate comparison of radiation and other effects. What is required is a quantitative index, and the report suggests one that takes account of the length of life lost as a result of occupational causes. The proposed index is expressed as the number of man-years lost per thousand man-years employed.

Calculations are presented to indicate that occupational radiation exposure at about 0.6 rem per year, which is commonly found among many groups of radiation workers, would yield a harm index comparable with that of many factory workers in the United Kingdom. Continual annual exposure of every worker at the ICRP limit of 5 rem per year would yield an index comparable with that applicable to construction work or coal-mining in many countries.

Others

Other private organizations which have set standards bearing on radiation protection in 1977 are the American Nuclear Society, the American Society for Testing and Materials, the American Society of Mechanical Engineers, the Health Physics Society, the Institute of Electrical and Electronics Engineers, the American Institute of Chemical Engineers, the Institute of Nuclear Materials Management, the International Commission on Radiation Units and Measurements, the National Fire Protection Association, and the Underwriters Laboratories.

APPENDIX D

Charts of Organization

Figure 1 Summary Diagram of Major Federal Radiation Protection Functions

Figure 2 Environmental Protection Agency

Figure 3 Energy Research and Development Administration

Figure 4 Bureau of Radiological Health

Figure 5 Nuclear Regulatory Commission

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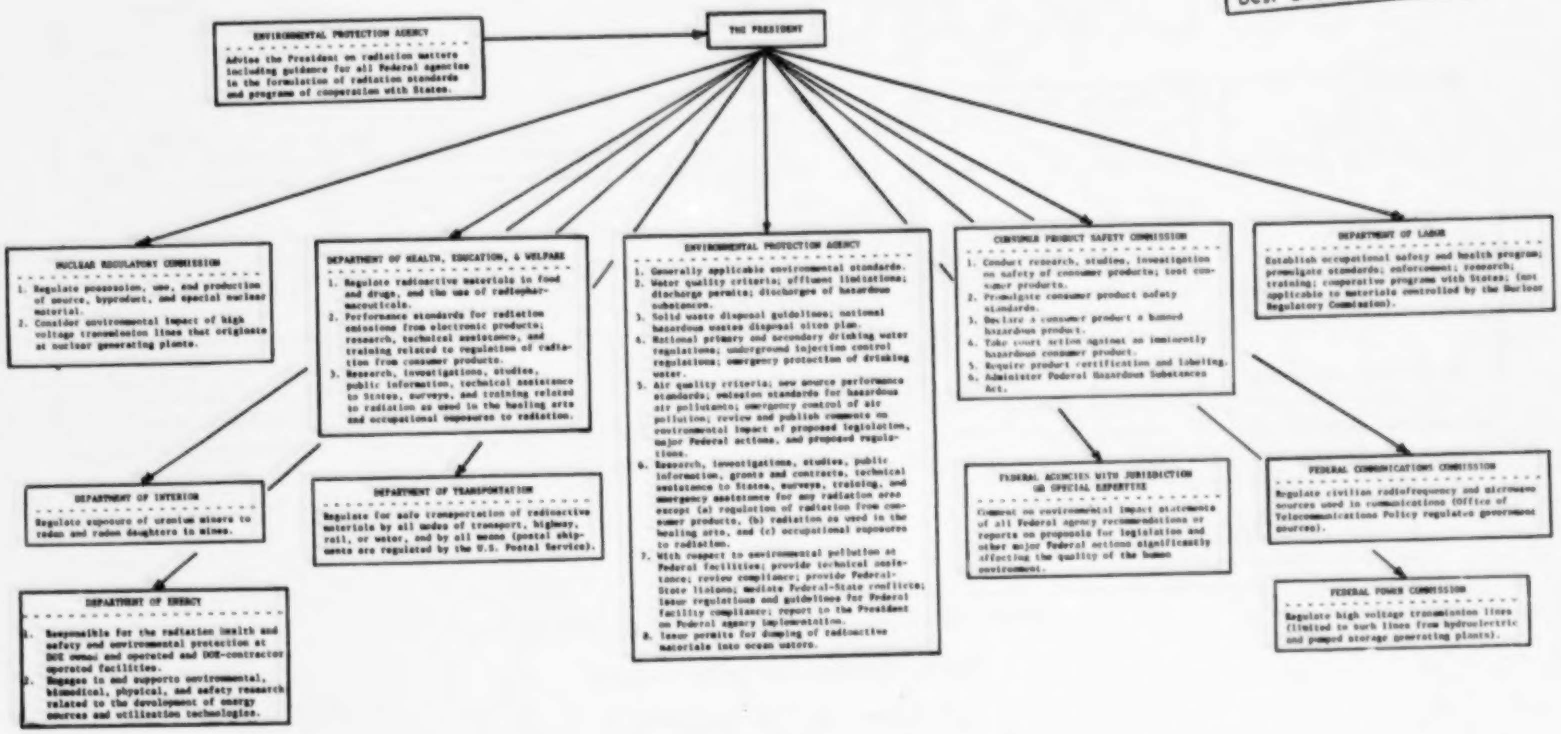
SUMMARY DIAGRAM OF MAJOR FEDERAL RADIATION PROTECTION FUNCTIONS



THE PRESIDENT

ENVIRONMENTAL PROTECTION AGENCY

Advise the President on radiation matters including guidance for all Federal agencies in the formulation of radiation standards and programs of cooperation with States.

NUCLEAR REGULATORY COMMISSION

1. Regulate possession, use, and production of source, byproduct, and special nuclear material.
2. Consider environmental impact of high voltage transmission lines that originate at nuclear generating plants.

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE

1. Regulate radioactive materials in food and drugs, and the use of radiopharmaceuticals.
2. Performance standards for radiation emissions from electronic products; research, technical assistance, and training related to regulation of radiation from consumer products.
3. Research, investigations, studies, public information, technical assistance to States, surveys, and training related to radiation as used in the healing arts and occupational exposures to radiation.

DEPARTMENT OF INTERIOR

Regulate exposure of uranium miners to radon and radon daughters in mines.

DEPARTMENT OF ENERGY

1. Responsible for the radiation health and safety and environmental protection at DOE owned and operated and DOE-contractor operated facilities.
2. Engages in and supports environmental, biomedical, physical, and safety research related to the development of energy sources and utilization technologies.

DEPARTMENT OF TRANSPORTATION

Regulate for safe transportation of radioactive materials by all modes of transport, highway, rail, or water, and by all means (postal shipments are regulated by the U.S. Postal Service).

ENVIRONMENTAL PROTECTION AGENCY

1. Generally applicable environmental standards.
2. Water quality criteria; effluent limitations; discharge permits; discharges of hazardous substances.
3. Solid waste disposal guidelines; national hazardous wastes disposal sites plan.
4. National primary and secondary drinking water regulations; underground injection control regulations; emergency protection of drinking water.
5. Air quality criteria; new source performance standards; emission standards for hazardous air pollutants; emergency control of air pollution; review and publish comments on environmental impact of proposed legislation, major Federal actions, and proposed regulations.
6. Research, investigations, studies, public information, grants and contracts, technical assistance to States, surveys, training, and emergency assistance for any radiation area except (a) regulation of radiation from consumer products, (b) radiation as used in the healing arts, and (c) occupational exposures to radiation.
7. With respect to environmental pollution at Federal facilities; provide technical assistance; review compliance; provide Federal-State liaison; mediate Federal-State conflicts; issue regulations and guidelines for Federal facility compliance; report to the President on Federal agency implementation.
8. Issue permits for dumping of radioactive materials into ocean waters.

CONSUMER PRODUCT SAFETY COMMISSION

1. Conduct research, studies, investigation on safety of consumer products; test consumer products.
2. Promulgate consumer product safety standards.
3. Declare a consumer product a banned hazardous product.
4. Take court action against an imminently hazardous consumer product.
5. Require product certification and labeling.
6. Administer Federal Hazardous Substances Act.

FEDERAL AGENCIES WITH JURISDICTION OR SPECIAL EXPERTISE

Comment on environmental impact statements of all Federal agency recommendations or reports on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment.

DEPARTMENT OF LABOR

Establish occupational safety and health program; promulgate standards; enforcement; research; training; cooperative programs with States; (not applicable to materials controlled by the Nuclear Regulatory Commission).

FEDERAL COMMUNICATIONS COMMISSION

Regulate civilian radiofrequency and microwave sources used in communications (Office of Telecommunications Policy regulates government sources).

FEDERAL POWER COMMISSION

Regulate high voltage transmission lines (limited to such lines from hydroelectric and pumped storage generating plants).

FIGURE 1

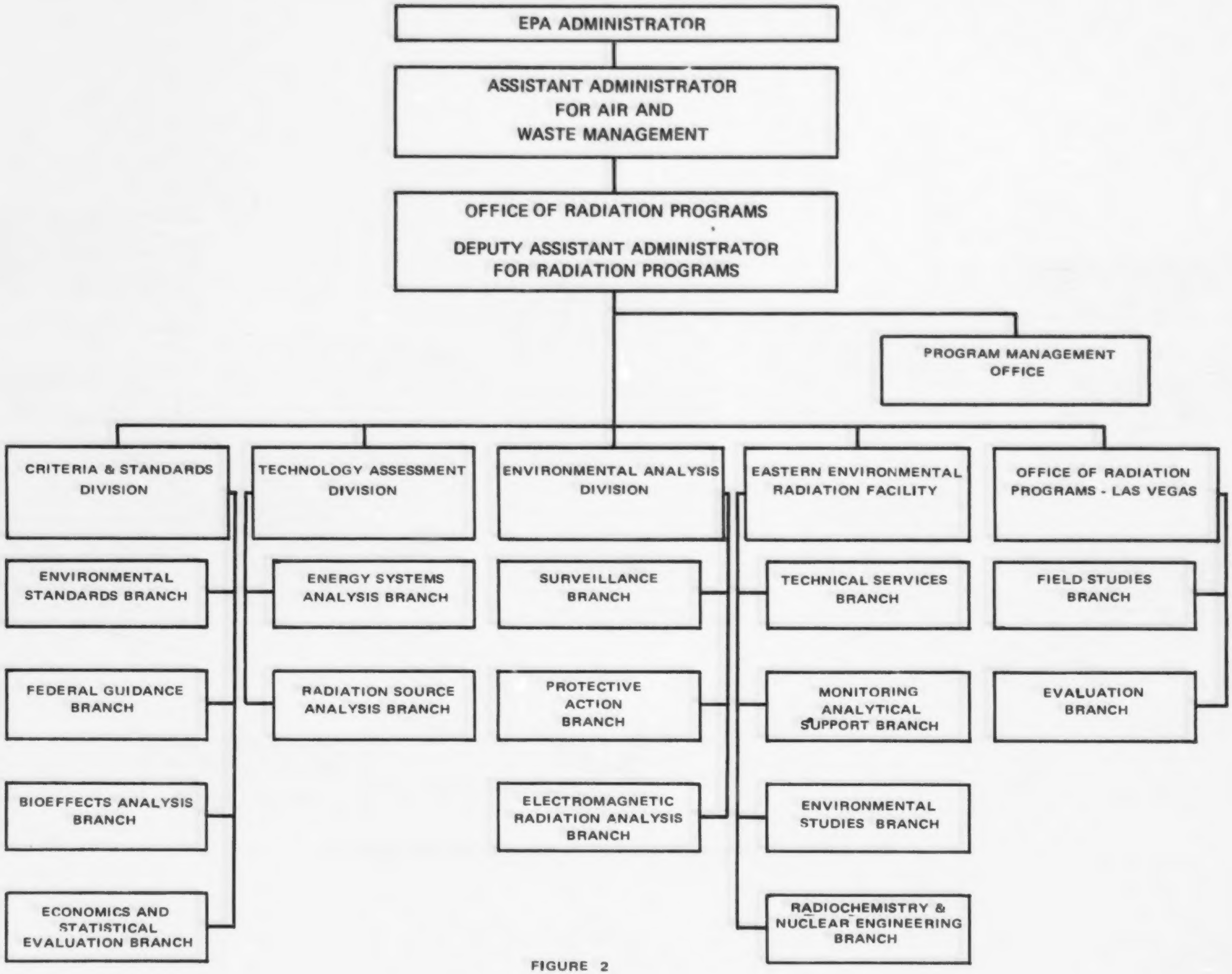
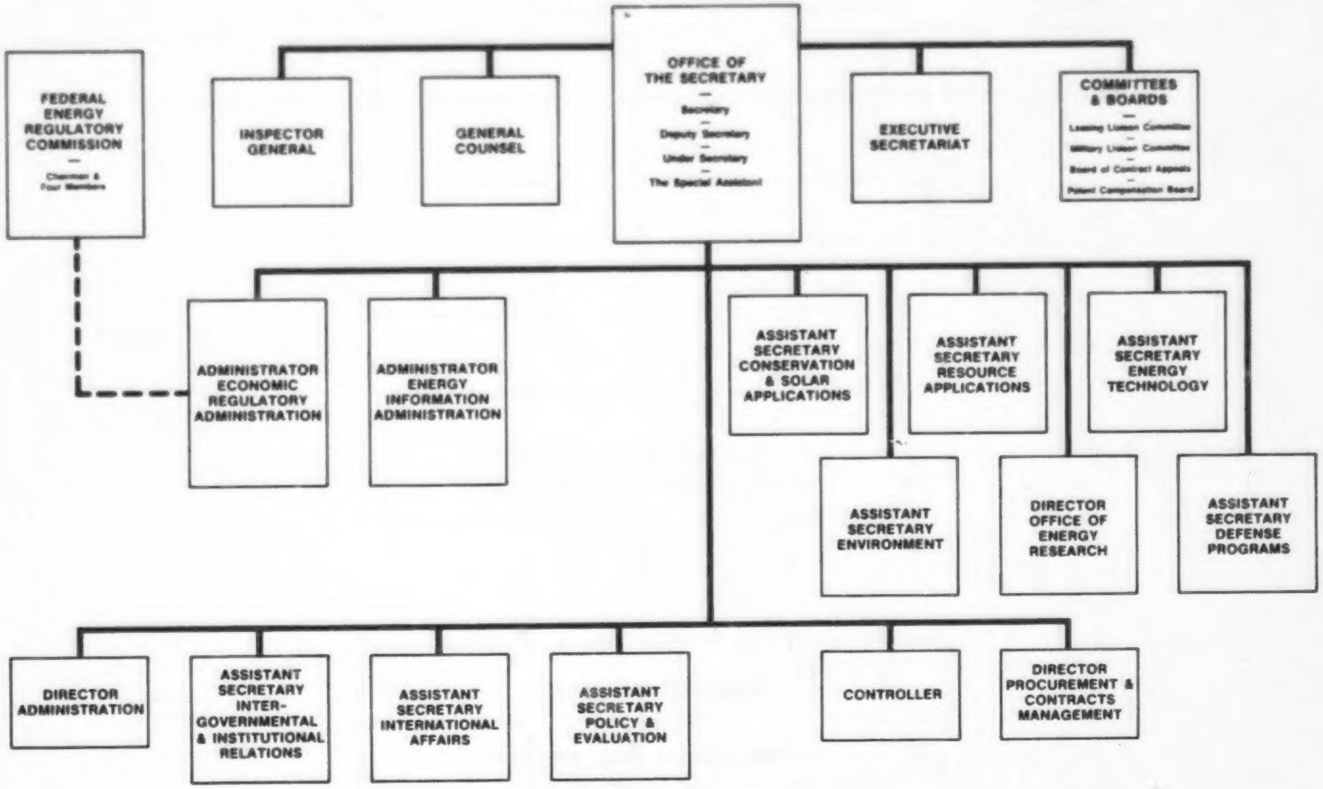

EPA ADMINISTRATOR
ASSISTANT ADMINISTRATOR FOR AIR AND WASTE MANAGEMENT
OFFICE OF RADIATION PROGRAMS
DEPUTY ASSISTANT ADMINISTRATOR FOR RADIATION PROGRAMS
PROGRAM MANAGEMENT OFFICE
CRITERIA & STANDARDS DIVISION
ENVIRONMENTAL STANDARDS BRANCH
FEDERAL GUIDANCE BRANCH
BIOEFFECTS ANALYSIS BRANCH
ECONOMICS AND STATISTICAL EVALUATION BRANCH
TECHNOLOGY ASSESSMENT DIVISION
ENERGY SYSTEMS ANALYSIS BRANCH
RADIATION SOURCE ANALYSIS BRANCH
ENVIRONMENTAL ANALYSIS DIVISION
SURVEILLANCE BRANCH
PROTECTIVE ACTION BRANCH
ELECTROMAGNETIC RADIATION ANALYSIS BRANCH
EASTERN ENVIRONMENTAL RADIATION FACILITY
TECHNICAL SERVICES BRANCH
MONITORING ANALYTICAL SUPPORT BRANCH
ENVIRONMENTAL STUDIES BRANCH
RADIOCHEMISTRY & NUCLEAR ENGINEERING BRANCH
OFFICE OF RADIATION PROGRAMS - LAS VEGAS
FIELD STUDIES BRANCH
EVALUATION BRANCH

FIGURE 2

DEPARTMENT OF ENERGY


FEDERAL ENERGY REGULATORY COMMISSION
—
Chairman & Four Members
INSPECTOR GENERAL
GENERAL COUNSEL
OFFICE OF THE SECRETARY
—
Secretary
—
Deputy Secretary
—
Under Secretary
—
The Special Assistant
EXECUTIVE SECRETARIAT
COMMITTEES & BOARDS
—
Leasing Liaison Committee
—
Military Liaison Committee
—
Board of Contract Appeals
—
Patent Compensation Board
ADMINISTRATOR ECONOMIC REGULATORY ADMINISTRATION
ADMINISTRATOR ENERGY INFORMATION ADMINISTRATION
ASSISTANT SECRETARY CONSERVATION & SOLAR APPLICATIONS
ASSISTANT SECRETARY RESOURCE APPLICATIONS
ASSISTANT SECRETARY ENERGY TECHNOLOGY
ASSISTANT SECRETARY ENVIRONMENT
DIRECTOR OFFICE OF ENERGY RESEARCH
ASSISTANT SECRETARY DEFENSE PROGRAMS
DIRECTOR ADMINISTRATION
ASSISTANT SECRETARY INTER-GOVERNMENTAL & INSTITUTIONAL RELATIONS
ASSISTANT SECRETARY INTERNATIONAL AFFAIRS
ASSISTANT SECRETARY POLICY & EVALUATION
CONTROLLER
DIRECTOR PROCUREMENT & CONTRACTS MANAGEMENT

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

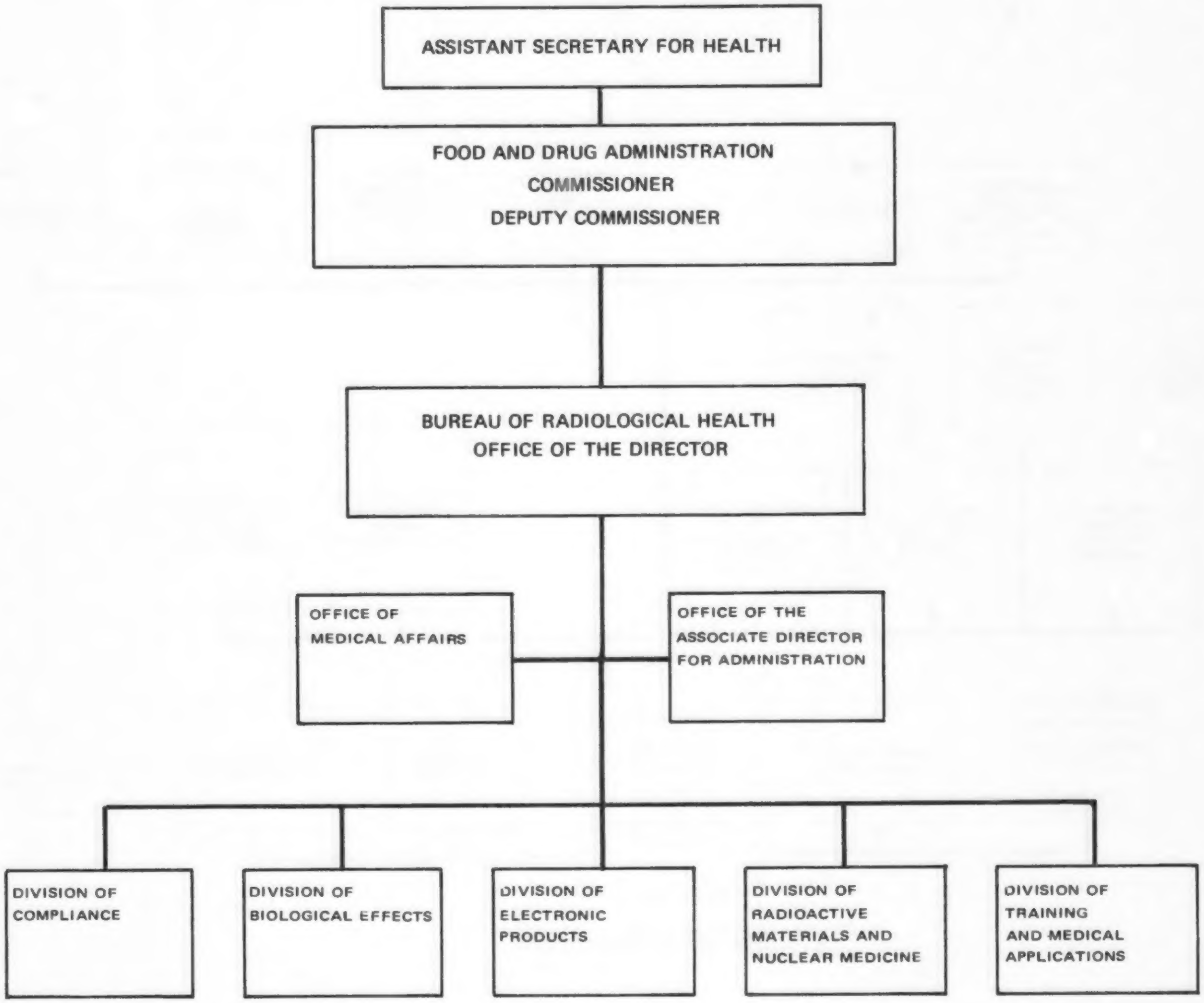

ASSISTANT SECRETARY FOR HEALTH
FOOD AND DRUG ADMINISTRATION COMMISSIONER DEPUTY COMMISSIONER
BUREAU OF RADIOLOGICAL HEALTH OFFICE OF THE DIRECTOR
OFFICE OF MEDICAL AFFAIRS
OFFICE OF THE ASSOCIATE DIRECTOR FOR ADMINISTRATION
DIVISION OF COMPLIANCE
DIVISION OF BIOLOGICAL EFFECTS
DIVISION OF ELECTRONIC PRODUCTS
DIVISION OF RADIOACTIVE MATERIALS AND NUCLEAR MEDICINE
DIVISION OF TRAINING AND MEDICAL APPLICATIONS

FIGURE 4

NUCLEAR REGULATORY COMMISSION

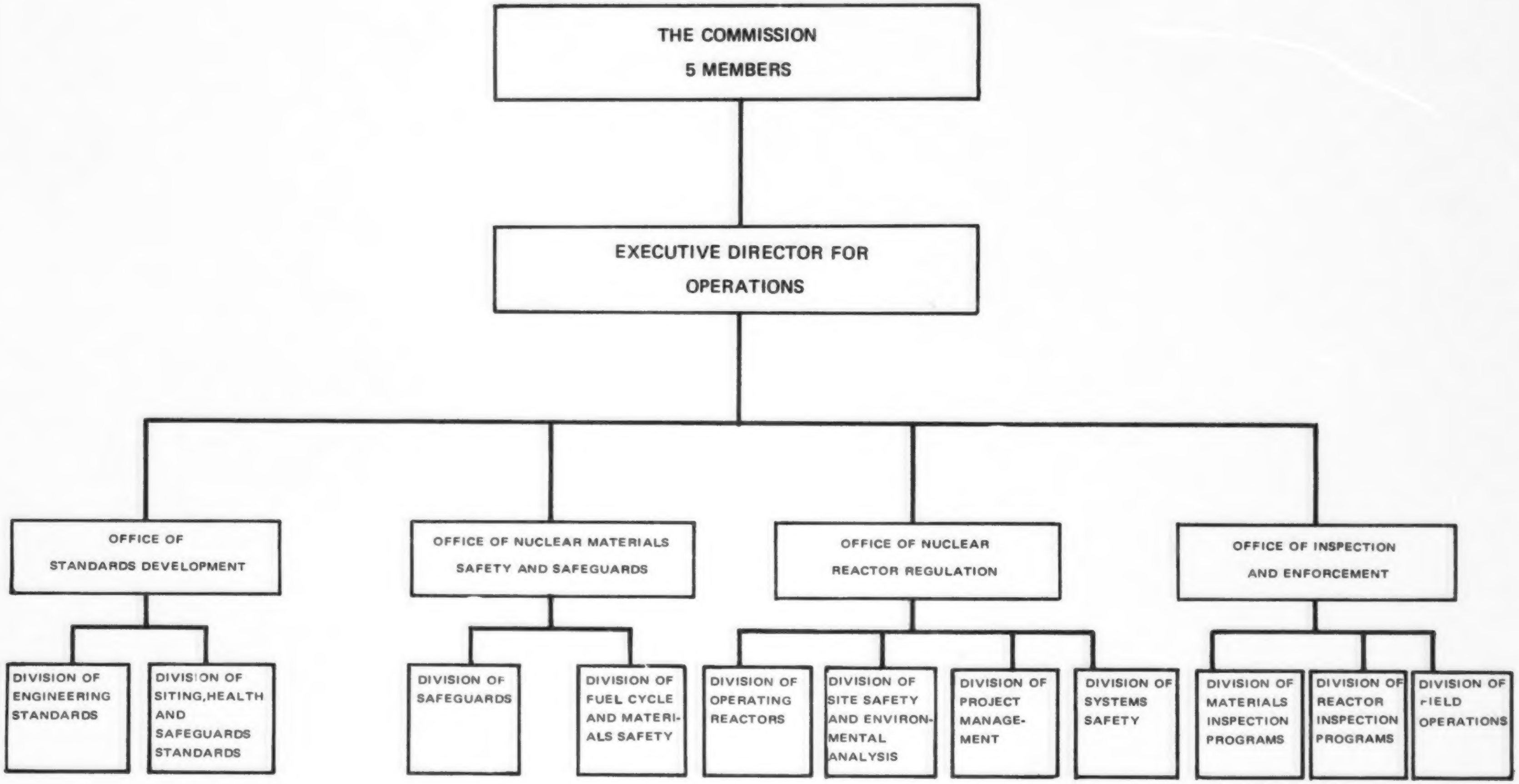

THE COMMISSION
5 MEMBERS
EXECUTIVE DIRECTOR FOR OPERATIONS
OFFICE OF STANDARDS DEVELOPMENT
DIVISION OF ENGINEERING STANDARDS
DIVISION OF SITING, HEALTH AND SAFEGUARDS STANDARDS
OFFICE OF NUCLEAR MATERIALS SAFETY AND SAFEGUARDS
DIVISION OF SAFEGUARDS
DIVISION OF FUEL CYCLE AND MATERIALS SAFETY
OFFICE OF NUCLEAR REACTOR REGULATION
DIVISION OF OPERATING REACTORS
DIVISION OF SITE SAFETY AND ENVIRONMENTAL ANALYSIS
DIVISION OF PROJECT MANAGEMENT
DIVISION OF SYSTEMS SAFETY
OFFICE OF INSPECTION AND ENFORCEMENT
DIVISION OF MATERIALS INSPECTION PROGRAMS
DIVISION OF REACTOR INSPECTION PROGRAMS
DIVISION OF FIELD OPERATIONS

FIGURE 5

APPENDIX E

ACRONYMS AND ABBREVIATIONS GLOSSARY

AEC	Atomic Energy Commission
ANSI	American National Standards Institute
BEIR	Biological Effects of Ionizing Radiation
BRH	Bureau of Radiological Health, Food and Drug Administration
CT	Computered Tomographic
DoD	Department of Defense
DoI	Department of Interior
DoT	Department of Transportation
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPA/ORP	Environmental Protection Agency/Office of Radiation Programs
ERAMS	Environmental Radiological Ambient Monitoring System
ERDA	Energy Research and Development Administration
FDA	Food and Drug Administration
FNP	Floating Nuclear Plant
F.R.	Federal Register
FWPCA	Federal Water Pollution Control Act
GAO	General Accounting Office, U.S. Congress
GEIS	Generic Environmental Impact Statement
GHz	Gigahertz, a unit of frequency (1,000 MHz)
GSD	Genetically Significant Dose
HEW	Department of Health, Education, and Welfare

HTGR	High Temperature Gas Reactor
Hz	Hertz, basic unit of frequency
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation Protection
LMFBR	Liquid Metal Fast Breeder Reactor
LOCA	Loss of Coolant Accident
LOFT	Loss of Fluid Test
LWR	Light Water Reactor
MESA	Mining Enforcement and Safety Administration, Department of Interior
MHz	Megahertz, a unit of frequency (1,000,000 hertz)
Microcuries	A unit of activity, abbreviated μCi (one-millionth of a curie)
Mrem	Millirem, a special unit of dose equivalent (1/1,000 rem)
mW	Milliwatt, a unit of power (1/1,000 watt)
NARM	Naturally-Occurring or Accelerator Produced Material
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards
NEPA	National Environmental Policy Act
NIOSH	National Institute of Occupational Safety and Health
NRC	Nuclear Regulatory Commission
NRDC	Natural Resources Defense Council
ORP	Office of Radiation Programs, Environmental Protection Agency
OSHA	Occupational Safety and Health Administration
OTP	Office of Telecommunications Policy
PAG	Protective Action Guide
pCi	Picocurie, a unit of activity (one millionth of a microcurie)

ppm	Parts Per Thousand
Rad	A unit of absorbed dose
Rem	A special unit of dose equivalent
RF	Radiofrequency
TLD	Thermoluminescent Dosimeter
USGS	U.S. Geological Survey
WL(M)	Working Level (Month), a unit of concentration based on one liter of air (one WL is any combination of short-lived decay products of radon that will result in emission of a certain amount of alpha ray energy)

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